

**Abdus Salam**

# **SCIENCE AND EDUCATION IN PAKISTAN**



**THE THIRD WORLD ACADEMY OF SCIENCES**

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Professor Abdus Salam receiving the Honorary Degree of Doctor of Science at the Aligarh Muslim University, Aligarh, India, January 1981.

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## The Editor's Introduction

As Pakistan approaches its fortieth anniversary in August, 1987, the state of science and education in Pakistan can bring little satisfaction to its people and friends abroad. Not only is illiteracy widespread, Pakistan has the dubious distinction of being ahead in literacy only of two Asian countries - Afghanistan and Nepal! Pakistan's per capita expenditure on education is one of the lowest in Asia. With a large part of its gross national product and bulk of its budget devoted to defence, Pakistan is currently spending US\$ 2,000 per soldier and only two dollars per student. If our national priorities are not rearranged soon, the economic, social and political fabric of Pakistan may degenerate to an unsustainable level.

Foreseeing this serious crisis, Professor Abdus Salam has been campaigning since his address to the All Pakistan Science Conference in Dhaka in January, 1961, for the development of science in Pakistan, for an enlightened educational framework in the country. Whatever modern science exists in Pakistan today was ushered in primarily through the assiduous efforts made by Professor Abdus Salam. Before Professor Abdus Salam became Science Adviser to the President Ayub Khan of Pakistan in 1961, he was active member of Pakistan Science Commission and Pakistan Education Commission in the late fifties. Professor Abdus Salam was the founder and first chairman of the Space and Upper Atmosphere Committee (SUPARCO) in 1962. It was through Professor Salam's persuasion and help that the Atomic Energy Commission embarked on the programme of training more than 500 scientists in areas of experimental and theoretical physics, nuclear chemistry, health physics, and agriculture. These men by and large constitute Pakistan's total stock of trained manpower in the relevant disciplines. The research establishment near Islamabad (PINSTECH), as well as the nuclear power plant near Karachi (KANUPP), owe much to his tireless efforts, as of Science Adviser, as do the National Science Council and the Pakistan Science Foundation. Before the Islamic Summit Conference was held in Lahore in 1974, Professor Salam prepared for the then Chairman of the Islamic Conference and Prime Minister of Pakistan, Mr. Zulfikar Ali Bhutto, the blueprint for an Islamic Science Foundation. The plan Professor Salam

conceived to promote science and technology in the Islamic world was finally adopted (though scaled down by a factor of twenty on paper and by factor of sixty in practice) by the Islamic Summit Conference in Taif in 1981.

Successive governments in Pakistan promised to promote science and education, in response to the fervent appeals made by Professor Abdus Salam, but the promises were not fulfilled. Science and education have not been high on the agenda of the rulers of Pakistan. As a result, Pakistan has been relegated to an inferior position even in the Third World. Much is made by the official spokesmen of economic growth in Pakistan. Whatever growth has taken place, however, is not reflected in our educational standards nor in the nation's science and technology institutions.

Professor Abdus Salam, Fellow of the Royal Society, who was the first Nobel Laureate from an Islamic country, demonstrated his commitment to science and education in Pakistan by donating his entire prize money to scholarships and assistance for poor and deserving students principally from Pakistan. (He did the same with his prize money from Atoms for Peace Award which he used to help Physics Laboratories at Government College Jhang, Lahore, Sahiwal, Islamia College Lahore, and Government High School Jhang. Unlike some other Nobel Laureates from the Third World, Professor Abdus Salam has not forgotten or forsaken his roots. Also, unlike most of the distinguished scientists from the Third World who reside in North America and Europe, Professor Abdus Salam has not given up his nationality (He is one of the two living Nobel Laureates in Sciences who are Third World nationals). He remains a devout, true and devoted son of Pakistan, and a tireless crusader for the Third World.

The eminent Indian Nobel Laureate, Rabindra Nath Tagore, founded "Shantiniketan" in Bengal, which became the intellectual cradle of Indian nationalism in the thirties. Through sustained efforts and worldwide lobbying, (which some thought would never succeed), Professor Abdus Salam founded in 1964 the (United Nations) International Centre for Theoretical Physics, in Trieste, Italy. Professor Abdus Salam had wanted the International Centre for Theoretical Physics to be established in Pakistan. When the proposal was initiated in early sixties, it won the favour of President Ayub Khan, but the

then Finance Minister saw no merit in the idea and withheld funds for its infrastructure. Another minister, who was directly responsible for science and technology in Pakistan in the sixties even went to the extent of instructing the Pakistani delegate to the International Atomic Energy Agency meeting in Vienna to vote against the proposal to shift the Centre to Pakistan. The Pakistani delegate (who now heads the Atomic Energy Commission in Bangladesh) adopted a more decent course by just remaining silent at this meeting. There is no Shantineketan in Pakistan for Professor Abdus Salam.

Generously supported by the Italian government, as well as by the International Atomic Energy Agency in Vienna and the United Nations Educational, Scientific and Cultural Organisation in Paris, the International Centre for Theoretical Physics in Trieste has attracted visits of around 25,000 scientists and researchers internationally - more than half of them from the Third World. Together with eminent scientists and scholars from the developed countries, the Third World scientists are able to carry out basic research of great value to the cause of science in the developing countries. Through this unique institution located 150 kilometers east of Venice, Professor Abdus Salam is endeavouring to create many "Salams" in the Third World, who can carry the torch of scientific progress in the nations of Asia, Africa and Latin America where intellectual darkness prevails and science is neglected.

Another imaginative step taken by Professor Abdus Salam has been the creation of the Third World Academy of Sciences to which belong around one hundred of the most prestigious scientists of the Third World. This Academy has already created a niche for itself among the World Science Academies; its inauguration was carried out by the Secretary General of the United Nations. It awards Fellowships and Prizes to the Third World Scientists, of the order of two million dollars a year.

Professor Abdus Salam's fervent quest for basic research by Third World scientists is interlinked with the promotion of the scientific base of technology. "By and large few people realise", observes Professor Abdus Salam in one of his essays, "that technology transfer must always be preceded by science transfer".

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The message contained in the speeches of Professor Abdus Salam in this book deserves the unstinted attention and genuine support of all thinking Pakistanis who would like to see our country enter the next century not as a backward and ignorant nation, but as an enlightened society which can provide a better quality of life for its people. This book contains the address given last year by Professor Abdus Salam at the International Seminar in Nathiagali, a prestigious scientific forum which he founded, but which was not published in Pakistan for reasons best known to the organisers of the Seminar and the concerned authorities.

Professor Abdus Salam is not only an eminent scientist, recognised and honoured as such by the world community, he is also a sincere sage whose admonition and advice we can ignore only at our own peril. Opinion leaders, decision makers and thinking Pakistanis have a special duty in this regard. What Professor Abdus Salam has to say about the future of science and education in Pakistan should command their close interest and active involvement. They can and should create a climate of opinion in Pakistan whereby the leaders in command of its destiny are made aware of the urgent need to devote adequate resources and proper effort for the promotion of science and education in Pakistan.

NASIM AHMED

*London, February, 1987*

# A Note on Pakistan Science and Education

The Third World, as a whole, is slowly waking up to the realisation that Science and Technology are what distinguish the South from the North. On Science and Technology depend the standards of living of a nation. The widening gap in Economics and in Influence between the nations of the South and the North is basically the Science gap. It seems patently clear that there are two distinct types of humans inhabiting this globe of ours: those who are fully conversant with what Science and Technology can achieve; this confers upon them economic advantages as well as power to alter things. Then there are those who have NOT made Science and Technology part of their lives and who, by and large, are poor as well as influenceless.

*Table 1* gives figures for GNP expenditures on Science and Technology. One may note that while expenditures on Defence, on Education and on Health for the developing versus the developed world may differ, these do not show an order of magnitude difference. But, the expenditures on Science and Technology do differ by a factor of more than ten. *We in the South are just not serious about Science and Technology as a valid profession.*

**Table I**

**Defence, Education, Health, and Science and Technology  
Expenditure in US\$ (1983) (as % of GNP)**

	Population x (1,000)	GNP Million (US\$)	GNP Capita (US\$)	Defence (%)	Education (%)	Health (%)	Science and Technology
Ind. Countries	1,116,969	10,518,183	9,415	5.6	5.2	4.8	2.5
Dev. Countries	3,574,133	2,559,796	720	5.6	3.8	1.5	0.2
Pakistan	94,140	35,914	371	6.1	2.1	0.5	< 0.2
India	735,596	192,912	262	3	3.2	0.9	> 0.5

## 1. The Situation in Pakistan

There are four areas of Science and Technology:

1. Basic Sciences (Physics, Chemistry, Mathematics and Biology)

2. Applied Sciences (Agriculture, Energy (including Nuclear and Non-Conventional), Environment, Earth Sciences (including Minerals, Seismology)).

3. Classical Technology (Bulk Chemicals, Iron and Steel, Metals, Power Generation)

4. Science-Based High Technology (Microelectronics, Microprocessors, Computer-aided Design, High  $T_c$  Superconductors, Lasers, Fibre Optics, Fine Chemicals, Biotechnology, Space Science).

The Pakistan situation can be summarised in a few words. Research in Basic Sciences does not exist. High Technology is not a word which has entered into current usage in our country.

## 2. The Percentage of Our Manpower in the Educational System

(See Table II). At the primary level, we are depriving half of our young people even of the knowledge of the three R's. At the secondary and tertiary levels, we are not producing enough people who are technologically trained.

**Table II**  
**Enrollment Ratios by Age Groups**

	6-11 years of age	12-17 years of age	Professional Versus Liberal Secondary Education	18-23 years of age	University Level (Science, Engineering, Medicine/Arts and Law)
Pakistan	45%	13.5%	10/90	3%	25/70
Average Developing Countries	64%	38%		8.7%	
Average Developed Countries	94%	86.5%	50/50	30%	50/50

(1977 World Bank Figures)

## **Remedies**

2.1. At the higher levels, for Science (Pure and Applied) and Science-based High Technology, the number of researchers and the numbers of research places must increase. (China had less than 500 researchers in 1949 manning all its research institutions. It now has 300,000 – a factor of 600 increase over 40 years). We must emulate China.

2.2. We must broaden the base of our education so far as the three R's are concerned. (The easiest to teach, in my opinion, is Arithmetic – addition, subtraction and multiplication. *Everyone* in Pakistan must learn to count. Next comes reading, and particularly science-text reading).

2.3. The real change would come at the secondary stage where, instead of a multiplicity of organisations as at present, which deal with the technical, vocational, agricultural and commercial education, we should have just one Authority.

This Authority will be charged with creating (parallel with the present liberal system of education in arts and sciences) the *professional* system of education. Each award – the matriculation, the intermediate, the B.A. (or B.Sc.) – may be obtained either after the present *liberal* courses in arts or sciences, or after technical, vocational, agricultural, or commercial courses. (Thus, assuming that the intellectual content of a course in *Sewage* is as high as the intellectual content of a course in *Geography* at the B.Sc. level – and this is the case, for example, at Cambridge – a B.Sc. degree should be awarded to the person who pursues *Sewage* as a subject of study. Likewise, *Plumbing* may qualify for the matriculation). So far as job opportunities are concerned, *all* B.A.s (general, agricultural, technical, commercial), *all* intermediates (general, agricultural, technical, commercial), all matriculates of whatever variety would count as equivalent. Only thus will the exclusive hold on the public mind – particularly on parents' minds – of the present prestigious *liberal* system of education be broken. (Adding new technical, agricultural or commercial streams to the present high schools or colleges, and thus making them *comprehensive*, may obviate the necessity of a vast new building programme).

#### **2.4. *Industrial Research and Development Training Centres***

Time has come when the more mature of Pakistan's industries – textiles, paper, sugar, cement, fertilizers, gas, fuel refining, telecommunications and the steel and metallurgical industries – should support their own research and development establishments, the units in each industry either acting individually or in concert. To provide the gentle persuasion so necessary in our country there will be need for a statutory levy (depending on size) in addition to government funds for commissioning the projected research and training establishments located with each industry. The important point being made is that these establishments should be (a) mono purpose and (b) should be located within the relevant industry.

One may go right down the line to consider industries, like chassis-building or sports-goods or cutlery, and envisage following something like the present United Kingdom and Western European practice of setting up government-sponsored and industry-financed cooperative industrial research, development and training centres. In the United Kingdom there are at present some two dozen such government-sponsored Centres for baking and flour milling, brushes, cast-iron, cutlery and files, drop forging, gelatin and glue, glass, paints, springs, shoes, timber, lace, hosiery, welding and wool. In 1970, these institutions employed six thousand scientists, spent 13 million pounds sterling and served the needs of industries with a turn-over of around forty billion pounds. These Centres bring the knowledge of the newest technical advances to the manufacturer.

The pattern for industrial research, development and training which is being advocated here is somewhat different from the one we have so far pursued. Different is perhaps not the right word – the new pattern is a logical development of past practice, necessitated by our growing maturity. In this pattern the emphasis is on statutory participation by industry, with Government sponsorship, of the research, development and training centres.

**2.5** So far we have considered the lower echelons of research, development and training. Money lies with High Technology today, as the experience of Japan, South Korea, Taiwan and Singapore has demonstrated. It may be recalled that Singapore is currently earning 1.7 billion dollars from

multinationals attracted to it by the high level of scientifically and technologically trained manpower. Likewise, Israel is earning 1.2 billion from exports of high technology. The higher echelons of our educational system will need the setting up of *Basic Sciences and High Technology Institutions* throughout the country. The one at the apex, to be set up in the capital city, would be designated as *The Institute of Science and High Technology*. It would be a postgraduate *world-class* institution, training in the first place for the M.Sc., and the Ph.D. levels.

(a) It may be set up with trust funds within the private sector so that it may attract overseas foreign staff as well as Pakistanis of superlative quality. (It may thus avoid the dread hand of government bureaucracy in this manner).

(b) Such an institution must be international in character (at least with a high foreign student population). This may help in obtaining United Nations, World Bank, as well as bilateral funds from foreign donors.

(c) Such a postgraduate institute will be supplemented in a supportive role by degree-giving institutions at the divisional level with the involvement of SUPARCO.

(d) If it is considered desirable to set up more than one such institute for Science and High Technology, it may be desirable to have competition among donors, like for the case of the I.I.T.'s (Indian Institutes of Technology) where the U.S., the U.K., the U.S.S.R. and German government consortia competed for the setting up of the I.I.T.'s at Kanpur, Delhi, Bombay and Madras.

(e) Blueprints and plans may be drawn up for an apex type of *Applied Sciences and Classical Technology Research Institute* in specified areas with the help of Applied Science organisations and Universities of Engineering.

2.6 To combat scientific illiteracy, it is essential that we should adopt Urdu as the medium of instruction. The type of Urdu which should be encouraged is exemplified by the advertisement which is appended to this note from a PIA publication. A translation bureau would be set up to translate scientific publications including the *Scientific American* and the *New Scientist*. The

idea is that science studies should not be considered as a vehicle to teach English (nor Persian, nor Arabic). The Urdu used for Science would freely incorporate English vocabulary to keep abreast of international usage – thereby enriching Urdu (like Amir Khosrau did when he formalised Urdu in the early 14th century, with Hindi words to take care of the Science of Music). At a still higher level, scientific journals and scientific books will be reproduced in English and disseminated at a subsidised cost, like China does, so that no scientific institution in Pakistan is deprived of scientific literature.

**2.7** The Third World Academy of Sciences has recommended that the equivalent of 4% of the education budget should be spent on research in Basic Sciences, 4% on research in Applied Sciences while 8% should be spent in development of science-based high technology. This would mean for Pakistan an outlay of 120 million dollars a year (1983 dollars) constituting 0.32% of the GNP. This level will be attained after five years.

**2.8** I feel very strongly that since 1/8th of the Holy Book speaks of science and technology – Taffaqur and Taskheer ( *تفكير و تسخير* ) – (1/8th of the Zakat funds as well as 1/8th of the funds from the Auqaf should be set aside for poverty-relieving scientific education. An Editorial from the *Dawn Daily* of 26 November 1987 is reproduced below; this Editorial may well have quoted the saying of the Holy Prophet of Islam, Peace and Blessing of Allah be upon him, *يَكَادُ أَنْ يَكُونَ الْفَقْرُ كُفْرًا*. (It is near that poverty may become synonymous with *Kufr*).

**2.9** A Commission should be set up by the Government to consider and enhance career patterns for scientists.

### A Dawn Editorial Regarding Zakat Funds

*Deeni Madaris* appear to have claimed a lion's share of Zakat money. They received an estimated 9.40 million rupees in 1980-81 and 68.5 million rupees in 1986-87. As expected, this has led to a rapid increase in the number of *Deeni Madaris* during this period – from 636 in 1980-81 to 2,084 in 1986-87.

In contrast, the allocation to vocational and social welfare institutions was reduced from 7.13 million rupees in 1980-81 to 4.50 million rupees in 1986-87. The point to stress is that vocational and welfare institutions teach skills and train individuals for earning a living for themselves and for their families. This cannot be said, however, as emphatically about *Deeni Madaris* whose contribution to making its pupils economically self-reliant or prospective bread-winners for their families is at best debatable. Besides, providing religious education to those seeking it is a governmental responsibility and should not be made a major charge on the Zakat funds which are meant primarily to help the poor and relieve economic destitution... -Dawn, Nov. 86



Examples of Bazaar Urdu.

## ڈیوٹی فری شاپس لمیٹڈ ایک تصور حقیقت کا روپ دھار چکا ہے

**ڈیوٹی فری شاپس** جدید دنیا کا ایک اچھا نامہ و خریداری ہے دنیا کے ملکوں کے درمیان تجارت کی بڑے پیمانے پر آمد و رفت، فضائی سفر و فضا کو زیادہ سے زیادہ سہولتوں کی فراہمی اور ضروریات زندگی کی اشیاء کو معافیت کا حق پر مشتمل تجارت کرنے کے مقاصد پر سے کرتا ہے۔ پاکستان میں ڈیوٹی فری شاپس کا نام گزشتہ چند برسوں کے دوران خاصا مانوس ہو گیا ہے۔ فضائی مسافروں کو خریداری کی سہولت کی فراہمی کا آغاز کراچی میں پہلی ڈیوٹی فری شاپ کے قیام سے ہوا۔ اس کے بعد لاہور میں اور پھر اسلام آباد میں ڈیوٹی فری شاپنگ کمپلیکس کے ذریعہ ایسی ہی سہولت فراہم کر دی گئی۔

ڈیوٹی فری شاپس اور فضائی سفر میں ایک گہرا تعلق اور رابطہ ہے یہ بلاشبہ ایک نیا تقابلیہ ہے لیکن اس تصور کو ایک خصوصی اہمیت حاصل ہے ڈیوٹی فری شاپس کے قیام کا ایک مقصد تو خریداری کی ایسی سہولت مہیا کرنا ہے جو عام طور پر بیرون میں دستیاب نہیں۔ دوسرا فائدہ ان ڈیوٹی فری شاپس کا یہ ہے کہ وہ خریدار اور فروخت کنندہ کے مابین ایک ایسے رابطے کو فروغ دیتی ہیں جسے اگر سوچ بوجھ کے ساتھ استعمال کیا جائے تو تینوں طرف سے والے پاکستانیوں کا دل جیسے کا سبب بن سکتا ہے جو بیرون ملک محنت و مشقت کے طویل سال گزارنے کے بعد وطن لوٹتے ہیں۔

اس بات کی پوری کوشش کی جاتی ہے کہ ڈیوٹی فری شاپس پر نہ دو دنوں سہولتیں بہتر انداز میں اور کامیاب طریقے پر پیش کی جائیں۔ جن واپس آنے والے پاکستانی جیسے ڈیوٹی فری شاپ میں آتے ہیں تو نہ صرف یہ کہ ان کی خریداری کی ضروریات کسی خاص رانڈ اور ماڈل وغیرہ کے بارے میں ان کی پسندیدگی اور مناسب قیمت پر بین الاقوامی معیار کو اختیار کی فرمیں کا خیال رکھا جاتا ہے بلکہ ان کی وہ جذباتی کیفیت و مسرت و خوشی بھی پیش نظر رہتی ہے جو وہ وطن واپسی پر محسوس کر رہے ہوتے ہیں۔ پاکستان کے بین الاقوامی ہوائی اڈوں پر ڈیوٹی فری شاپنگ کی سہولتوں کا آغاز دسمبر ۱۹۷۹ء میں کیا گیا۔ کراچی میں ۱۹۷۹ء سے کراچی ایئر پورٹ کے ڈیپارچر ٹرمینل لاؤنج میں پہلی خوردہ ڈیوٹی فری شاپ نے اور ۱۹۸۱ء اپریل ۱۹۷۹ء سے اسلام آباد انٹرنیشنل ایئر پورٹ کے ڈیپارچر لاؤنج میں دوسری ڈیوٹی فری شاپ نے کام شروع کیا۔

بیرون ملک سے واپس آنے والے پاکستانی باشندوں کو انتہائی

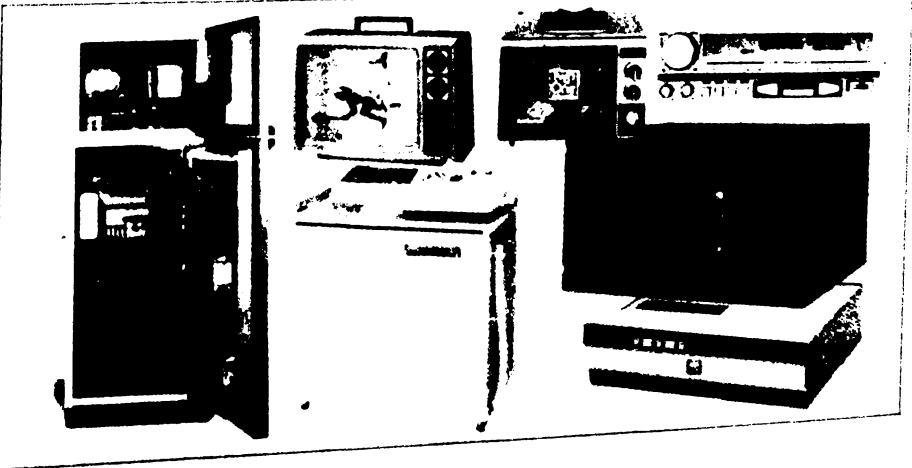


کراچی میں شارع فیصل پر ڈیوٹی فری شاپنگ کمپلیکس کی عمارت

دستوری اور تکلیف کا سامنا کرنا پڑتا ہے۔ ایکسز ایک آلات، گھر، ہواستال کی اشیاء اور اہل خانہ دوستوں کے لیے تحائف جو وہ اپنے ہمراہ لاتے ہیں ان پر بار برداری کے زیادہ اخراجات، ٹوٹ پھوٹ کے نقصان کا سامنا سامان ملنے میں تاخیر یا سامان کی گمشدگی اور ایریوٹ کے مجموعہ ماحول میں سامان بکیر کرنے میں دقت کا ضابطہ اور ذہنی ریشائی کا سامنا کرنا پڑتا ہے۔ چنانچہ واپس آنے والے پاکستانیوں کو ان تمام مسائل و مشکلات سے بچانے کے لیے دسمبر ۱۹۷۹ء میں کراچی اسلام آباد کے ہوائی اڈوں پر ایئر پورٹ لاؤنج میں ڈیوٹی فری شاپس قائم کی گئیں۔

اس کے بعد توسیع کے منصوبوں پر کام شروع ہوا، ہوائی اڈوں کی حدود سے باہر ایک وسیع ڈیوٹی فری شاپنگ کمپلیکس کے قیام کا جائزہ لیا گیا جہاں بیرون وطن مقیم پاکستانی، وطن واپسی کے بعد بیکنگ رولز کے تحت زرمبادلہ میں ان اشیاء کی خریداری کر سکیں۔ اس منصوبے کے تحت پہلے شاپنگ کمپلیکس کا افتتاح ۲۷ مئی ۱۹۸۲ء کو کراچی میں ہوا۔

۳ دسمبر ۱۹۸۳ء کو لاہور میں اسی نوعیت کے کمپلیکس کا افتتاح ہوا۔ دو برس اثناء صارفین کی بڑھتی ہوئی تعداد اور سرپرستی کے پیش نظر کراچی کا کمپلیکس شارع فیصل پر زیادہ کشادہ جگہ پر منتقل کر دیا گیا اور آخری مرحلہ میں کراچی ۱۹۸۵ء سے اسلام آباد کے کمپلیکس نے کام شروع کر دیا۔



حال ہی میں کراچی کے ڈیوٹی فری شاپنگ کمپلیکس کو مکمل ہو کر کپور نواز ڈکرو باجی ہے۔ کمپنی نوکی تھیب سے کسٹمر سروس کے سہارا میں کافی بہتری آئی ہے۔ کپور نواز انڈیا کے اس محل سے اشیا اور فنڈز میٹھٹ میں کافی استحکام پیدا ہوا ہے۔ اسلام آباد ڈیوٹی فری شاپنگ کمپلیکس میں کمپنی نے یکم اکتوبر ۱۹۸۵ء سے اور لاہور میں یکم دسمبر ۱۹۸۵ء سے کام شروع کر دیا ہے۔ کراچی کمپنی ٹرڈوٹن مرکزی بیٹین کے طور پر کام کر رہا ہے۔

خریدار کو سامان کی فراہمی میں جو دقت لگتا تھا، کمپنی نے رگائے جانے کی وجہ سے یہ دیوری کم دقت میں مکمل ہو گئی ہے کیونکہ اشیا کا تجربہ کرنا اور مناسب یا مطلوب سامان کا انداز آسان ہو گیا ہے۔ یہ کمپنی ٹرڈوٹن کے بارے میں تمام ریکارڈ رکھنے کے علاوہ فروخت کا بالکل درست تجربہ بھی تیار کرتا ہے جس سے تینوں کمپلیکس کے لیے فروخت کی تحریک عملی تیار کرنے میں مدد ملتی ہے۔

ڈیوٹی فری شاپس نے اپنے خریداروں کو دو اور سہولتیں فراہم کر رکھی ہیں۔ ان میں سے ایک پیشگی بکنگ کی سہولت ہے اور دوسری "آف دی شیلف سیل" کی پیشگی بکنگ کا مطلب ہے یہ کہ وطن آنے سے پہلے بیرون ملک آپ نے کوئی ایسی چیز بھی جو آپ خریدنا چاہتے ہیں اور موجود قوانین کے تحت اس شے کی پاکستان میں درآمد و پ کے لیے خریداری ممکن ہے تو آپ اپنی آمد سے پہلے اس چیز کے بارے میں ڈیوٹی فری شاپس کو خط لکھ کر مطلع کریں۔ اگر آپ کی مطلوب چیز اشیا میں نہیں ہوگی تو آپ کی آمد سے پہلے اس کی مندرجہ ذیل کا انتظام کر لیا جائے گا اور وطن پہنچنے پر آپ کے لیے اپنی پسندیدگی چیزوں کا حصول ممکن ہوگا۔ "آف دی شیلف سیل" کے تحت کراچی، لاہور اور اسلام آباد کے ڈیوٹی فری شاپنگ کمپلیکسز میں آپ اپنی پسندیدگی کوئی بھی چیز فوری طور پر خرید سکتے ہیں اور وہیں کرشم کی ادائیگی کے بعد فوری ڈیلیوری حاصل کر سکتے ہیں۔

ڈیوٹی فری شاپس میں مختلف اشیاء کی کم و بیش تین ہزار اقسام نہایت مناسب قیمتوں پر فروخت کے لیے پیش کی جاتی ہیں۔ ڈیوٹی فری شاپس کی کوشش ہوتی ہے کہ اپنے خسریداروں کو ان کی ضرورت کی زیادہ سے زیادہ چیزیں ایک ہی جھٹ کے نیچے فراہم کر دی جائیں آپ کو یہاں ریفریجریٹر اور ٹیلی ویژن سیٹ سے چاکلیٹ اور پیئرنگ — اور ملبوسات مصوٰعی زبورات سے ستر کی چادروں اور جینز تک — سب کی کچھ نظر آتا ہے۔ عالمی منڈی سے سستی اور معیاری اشیاء کا انتخاب اور صارفین کو معیاری سامان کی پیشکش ڈیوٹی فری شاپس کی مقبولیت کا ایک بڑا سبب ہے۔

ڈیوٹی فری شاپس نے "سوہنی دھرتی" کے نام سے ایک ریڈیو پروگرام بھی شروع کیا ہے جو ہر جمعہ کو پاکستانی وقت کے مطابق راجے نشر کیا جاتا ہے اس دلچسپ پروگرام میں پاکستان کی ڈیوٹی فری شاپس میں خریداری کے امکانات سے باخبر رکھا جاتا ہے اور سوالات کے جوابات بھی دیتے جاتے ہیں۔ ڈیوٹی فری شاپس میں خریداری کے طریقہ کار اور موجودہ بیکنگ رولز کے بارے میں معلومات حاصل کرنے کے لیے ڈیوٹی فری شاپس کے کراچی کے پتے پر خط کیجئے۔

# On Pakistan Science 1986

*Lecture delivered to the Pakistan Planning Commission and at the Eleventh International Nathiagali Summer College, 22 June - 10 July 1986.*

أَشْهَدُ أَنْ لَا إِلَهَ إِلَّا اللَّهُ وَأَشْهَدُ أَنَّ مُحَمَّدًا عَبْدُهُ وَرَسُولُهُ

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ .

## 1 . Introduction

First and foremost, it is important to reemphasise that the Pakistani nation is not a small nation. It numbers 97 millions today, nearly equal in size to the population of Japan and double size of France or the United Kingdom.

2 . So far as Sciences are concerned, we, as part of the Muslim Ummah, have shared in a glorious past<sup>1</sup>. Unfortunately, the present in Sciences is not so glorious. Of all the civilisations on this planet, that of Islam (which includes Pakistan) is the weakest in the Sciences. One must realise that the Muslim community in the Indian sub-continent was never, at any epoch of history, strong in the Sciences. In all the Afghan and Mogul periods of our history, we cannot quote the name of a single world-class scientist (except that of Al-Biruni who visited India around 1000 A.D.). Our rulers (and their military regimes) were simply not interested in building up schools of learning or science. They were more interested in building mausolea for themselves as monuments to their empires. Regrettably, a similar tradition continues.

### 3. What is wrong with Pakistan's Science and Technology?

In my view, there are three things wrong with Pakistan's science and technology:

- i) There is no national commitment to acquiring and enhancing scientific knowledge among us - and no realisation that Science can be applied to national economic or other problems, as, for example, there was in Japan at the time of the Meiji Restoration around 1870. Then the Emperor took five oaths as part of Japan's new constitution. One of these oaths was: "Knowledge will be sought and acquired from any source with all means at our disposal, for the greatness of Imperial Japan".  
A consequence of this lack of commitment is that the number of active scientists in Pakistan is *sub-critical*, and *dwindling* as the years go on; likewise for the outlay on the Sciences.
- ii) The enterprise of Science in our countries is not run by young, vigorous, working scientists as is the tradition elsewhere. Barring a few exceptions, our Universities do not create Science; outside the Universities, Pakistan is a veritable paradise of paper research organisations, with no mechanism for amalgamating or closing them, if they are not viable.
- iii) In technology, none of our governments has ever made it a national goal to acquire self reliance - even for defence technology. And we have paid scant heed to the scientific base of technology<sup>2</sup>.

I shall now elaborate on these points:

- i) ***No National Commitment.*** Pakistan may have a well defined foreign policy, a policy for imports and exports, we may have a policy for defence, but we certainly do not have any declared policy for science or technology. The last National Commission on this subject reported in 1959.

One aspect of this is that there is no commitment to *patronage of the Sciences* on the State - or the private - level. There is no policy of attracting our brighter intellects to the scientific profession. We give no priority to the growth of Science - even to Science in Defence - which, in my view, should receive a priority as high as the building up of conventional armed forces. Whatever science and technology we have in

the National Agricultural Council, or the Pakistan Atomic Energy Commission or SUPARCO, has come about through the efforts and initiative of individual entrepreneurs.

An example of how crucial such patronage can be, is provided by the history of the Academy of Sciences of the USSR. Forty years ago, the Soviet Academy of Sciences - first created by Peter the Great - was asked to *expand its numbers* and was set the ambitious task of excelling in all sciences. Today it numbers a self-governing community of a quarter of a million scientists working in its institutes, with priorities and privileges accorded to them in the Soviet system that others envy. According to Academician Malcev, this principally came about in 1945, at a time when the Soviet economy lay shattered by the war. Stalin decided to increase the emphasis on and the recruitment of bright young men and women into the Sciences. Acting against bureaucratic advice, he announced one day that the emoluments of all scientists and all technicians connected with the Soviet Academy would increase by a factor of three. There were "no increases for doctors or engineers", according to Academician Malcev, "only for scientists". Since then, there may be other problems with Soviet Science, but lack of patronage is certainly not one of them<sup>3</sup>.

A second aspect of this neglect is that Pakistan science is extremely small in terms of absolute size. Speaking of Physics, according to Mujahid Kamran (writing in the journal *Concept*), "the total number of physics teachers in all the universities of Pakistan is 86, of which only 46 have *Ph.Ds*".<sup>4</sup> This number has steadily declined since the 1970s when the exodus to the Middle East started. According to Professor Michael Moravcsik's estimates, Pakistan is one of the few countries in the Third World registering a net decline in terms of research publication at a time when the average for developing countries has increased by 40%.

To take one index, India - eight times the size of Pakistan in population - is annually producing 200 physics *Ph.Ds* in its own universities. Contrast this with Pakistan where the premier University, the Punjab University at Lahore, in its hundred years of existence, has not produced a single *Ph.D.* in Mathematics and only 3 in Physics (1982 Figures). According to Kamran: "While the basic reason for this is the inability of the political" - and, I might add, military - "leadership to grasp the fundamental role of science in nation building, the situation has been

greatly aggravated by the petty level and frame of mind of our bureaucracy... The bureaucracy is basically dominated by people without much interest in education" - and, I might add, science. "It predominantly comprises people whose own academic level has been rather mediocre ... Devoid of the feeling of wonder and awe, not feeling the soul-lifting thrill of ideas, the bureaucracy has always regarded education" - and science - "as one of the numerous services in the administrative structure and a rather unimportant one at that!".<sup>5</sup>

- ii) *The second thing which is wrong is the manner in which the enterprise of science is run.* Science depends for its advances on towering individuals. Conditions must be created so that such men remain in the country. Our enterprise of science must be run by working scientists themselves. Thus, when the late Amos de Shalit (then Director of the Weizmann Institute in Jerusalem) was asked in a UN Committee, what was the Israeli policy for science, his reply was: "We have a very simple policy for science growth, which consists of just two elements. First, a working scientist is always right and the younger he is, the more right he is. Second, we allow any scientist working in our universities or research organisations to travel freely, to migrate temporarily to anywhere in the world where his scientific work will flourish. We keep his position open at home, allowing him free mobility, provided just one condition is satisfied - that he marries an Israeli girl before leaving. She will eventually bring him back". This may have morals for us in Pakistan. I shall start with our Universities:

1. Our Universities must emphasise research - we must respect the norm that a University teacher devotes one half of his time to research and the other half to teaching. Also, at present, we do not insist on locating our national Research Institutes for applied subjects on University campuses or accord them University affiliation and status. This way we deprive our younger generation of contact with first class scientists who may be working at these institutes. We must stop this.
2. The continual strikes at Pakistan's universities and armed interruption of studies - sometimes murderously sanguine - do not help. It is incredible that a Martial Law Government should not have been able to guarantee the *Right to Study* of those - and this includes most science students - who

only wish to be left in peace to pursue their work. Such a *Right to Study* must be ensured.

3. Pakistan's scientific enterprise must maintain living contact with international science. (Today very few Pakistanis, if living and working in their own country, can travel to scientific institutions and meetings outside; such travel, as a rule, is considered a wasteful luxury<sup>6</sup>).
4. It is not just the physical isolation of the individual scientist that we suffer from. According to Zahlan, "There is also the isolation from the norms of international science, the gulf between the way we run the scientific enterprise and the self-governing manner in which it is run in the West" or within the community of scientists in the U.S.S.R. Academy. "We seem to have developed no system of professional organizations, no internal review committees, no independent studies of the state of art or of quality, no science foundations administered by the scientists, no independent sources of grants". (Of course, for lack of *professional organisations*, we must squarely place the blame on the scientists themselves. They have never banded together).
5. And finally, a significant factor, according to Kamran, "affecting research" is the appointment of "incompetent heads in educational institutions and research organisations ... With the two exceptions of the late Dr. Ishtiaq Hussain Qureshi and Dr. Mahmood Hussain of Karachi University (or of Dr. Saleem-uz-Zaman Siddiqui who served for a very short time) not a single research worker of calibre has been a Vice-Chancellor in our universities". A number had third class careers - and if they have ever indulged in research, that was when they were students. "This breed of institutional heads, instead of advocating measures for making university teaching" (and research) "an attractive profession, have done their best to do otherwise ... The resultant stress has forced our best people to leave this country or fall into a state of bitter frustration that has destroyed their creative faculties. It is therefore no wonder that resentment against Vice-Chancellors is wide-spread in universities ...

The result is a destructive tussle between the Vice-Chancellors and teachers in almost every university, which saps the energy of the teachers, affects the academic atmosphere adversely, and more than anything else, is the reason for the continuation of the brain drain".

In this context, Professor Michael Moravcsik's (see Appendix I) remarks

are relevant: "Furthermore, at least externally, there appears to be no realisation, or at least no admission, on the part of those who run Pakistani science policy that there is a problem. I find the quality of the science management in Pakistan today much too low, consisting of people with no personal experience in doing science, with no perception about the nature of science and its role in a country's development, and with no vision and no élan."

- iii) *There is no well defined technology policy and no understanding that science transfer must accompany technology transfer.* When we claim that we are encouraging the transfer of technology, often all this means is that we are importing designs, machines, technicians, and (sometimes even nearly processed) raw materials. The futility of this was stressed recently by Professor C.G. Oldham, the founder of the world-famous Science Policy Research Unit (SPRU) of the University of Sussex. Oldham was working in 1963 in Hong Kong as a geophysicist. He went to Geneva to attend the U.N. Conference on Science and Technology which gave him the inspiration for founding the Science Policy Research Unit. On the way back to Hong Kong, he was invited to break his journey at Tel Aviv.<sup>7</sup> This visit, he says, made him "realise the gulf which separated Hong Kong and Israel both peopled by refugees, similar in population and resources, but one that had placed its major emphasis on technology: while the other, in addition to technology, also relied on first-class science. One had become a power to reckon with - the other is still relatively developing". I believe, in this estimate, Oldham did not take into account other factors which have helped Israel and militated against Hong Kong; however, he was right in pointing out the contrast between situations where Technology is emphasised *with* Science and where *without*.

#### 4. Summary Recommendations

Notwithstanding the prior prognosis, there is no reason to feel despondent. Growth of Science at the highest possible level needs no more than one or two generations at most - as, for example, is evidenced by the examples of U.S., U.S.S.R. and Japan, and now Brazil, India, China, and lately, Korea. Here is a

survey of my recommendations:

- i) We need an absolute commitment to a policy of growth of high-quality science and its application to national problems, as well as to a declared commitment towards self-reliance in science based technology. Such a policy must recognise that science transfer must accompany technology transfer and that Science has a crucial place in national problem solving - in medicine and health, in agriculture, in prospecting, in our materials base, and in defence. In the building up of Science, we must follow Japan's lead (see Appendix III), the relevant elements of which were:
  1. The provision of *massive* and hard training to our younger generation in *all* fields of science and technology at all levels of education and research. To give examples of the massive scale needed for research training, note that the U.K. Science and Engineering Research Council (SERC) awards five thousand grants for Ph.D. training every year. An equal number is awarded by the other Research Councils - the Agricultural Research Council, the Medical Research Council, the Environmental Research Council and the like. The number of *post-Ph.D.* grants available within the U.K. (and outside), numbers one thousand every year. And the U.K. has only one half of the population of Pakistan. (It is a cruel thing to say, but even on an overall 25% literacy figure, the Pakistan nation should count at least as one half of the U.K. in scientific strength).  
The Pakistan Government has this year arranged to send 400 students abroad for Ph.D. studies. This is highly commendable and must be continued for many years, to make up for the neglect of two decades; linked awards must now be initiated for *post-doctoral* studies and, if necessary, we should institute special coaching for students who have been selected for higher studies abroad, by our senior scientists - as was done in 1918 in the U.S.S.R. where, according to Academician Emelyanov, senior scientists were asked to provide crash coaching to younger men and women, in order to build up rapidly the then very small cadre of scientists.
  2. The creation, in the long term, of first class Teaching and Research Institutes on the model of M.I.T. - the latter - even if engaged in Applied Research - must, as a rule be affiliated with our University<sup>8</sup> system.
- ii) We must change the way we administer science. Science must be run by and for the active scientists, and not by bureaucrats or by those whose science has ossified.

- iii) We must create Foundations of science, both endowed by the state and supported by private donations and Auqaf Funds,<sup>9</sup> so that a diversity of opportunities to secure grants for research is available.
- iv) We must make sure, with a generous provision, that our science is international in character. This must include paid leave, travel and subsistence grants for attending international symposia, seminars and conferences.
- v) To promote high technology, we could create an analogue of Japan's MITI (Ministry of Industry and Trade) in Pakistan. Notwithstanding its name, in practice, within Japan, MITI devotes itself to promotion of high technology. It assesses future scientific trends, promotes and encourages scientific research and, most crucial of all, it sets about bringing scientists together with investors, industrialists and government finance agencies.<sup>10</sup>
- vi) Regarding non-high technology industrial research, since most of our industry is small in size, we must consider the needs of the smaller units - for chassis building or for sports goods or for cutlery and the like. We should envisage following something like the United Kingdom (and Western European) practice of setting up joint government - and industry-sponsored cooperative institutions, for research and development, for industries like paints, cast-iron, cutlery and files, drop forging, gelatin and glue, glass, springs, shoes, lace, hosiery, welding and wool. In the U.K., such institutions employ six thousand scientists and technologists and spend some 100 million serving the needs of industries with a turnover of around 100 billion. I do not see why we could not have such research institutions for tiles in Multan, for pottery in Bahawalpur, for ceramics in Gujrat, for surgical instruments in Sialkot - locating some of the relevant components of the present Council of Scientific and Industrial Research at the places where they are needed most.
- vii) Since Pakistan's intellectual culture is almost completely dominated by a literary tradition of poetry, of ghazals, it is time that we tried actively to encourage and start a movement of "Halqai-Arbab-e-Science" with a proper balance among scientific activities embracing theory, experiment and innovation.

*What is crucial is that we set ourselves an ambitious goal in this respect through a state-declared policy. For example, like South Korea, we may nationally resolve to*

*emulate the United Kingdom in sciences by the end of the century.*

## 5. The importance of Science for Pakistan

Why am I so passionately advocating our engagement in the enterprise of Science and of creating scientific knowledge? It is not just because Allah has endowed us with the urge to know, nor because today scientific knowledge is power and applied science is the major instrument of material progress and meaningful defence; it is also because as self-respecting members of the international world community, we must face our responsibilities and pay back our debt due for the benefits we derive from the research stock of world science. Only thus can we avoid the contempt - unspoken, but certainly there - of those who create knowledge.

I can still recall a Nobel Prize Winner in Physics from a European country saying this to me some years ago: "Salam, do you really think we have an obligation to succour, aid, feed and keep alive those nations who have never created or added an iota to man's stock of knowledge?" And even if he had not said this, my own self-respect suffers whenever I enter a hospital and reflect that almost every potent life-saving medicament of today, from penicillin upwards, has been created without a contribution from any of us in Pakistan. In this context, I have recently been asking the Ulema in India, Bangladesh and Malaysia: since 1/8th - some 750 verses - of the Holy Book exhort the believers to "study Nature, to reflect, to make the best use of reason and to make the scientific enterprise an integral part of the community's life",<sup>11</sup> why don't they devote one out of every eight khutbas (in speaking in their Friday sermons) to Science? The uniform reply I have received is that they would like to, but they do not know enough Science themselves. Has not the time come when the curricula for religious seminaries should contain non-controversial parts of modern Sciences - such as Newton's laws, astrophysics, and a knowledge of the fundamental forces of nature, the genetic code, and the structure of the Earth?

6 . Let me conclude by going back to my starting point. Ours is a numerous - potentially a great - nation. Our tragedy is that we do not seem to realise this; we act in a narrow manner only befitting a small nation.

Our peoples have a natural endowment of first-class talent in Sciences once it is developed. I am not saying this as a starry-eyed patriot. I know this from experience after a life time of supervising researchers of many nationalities.

Likewise, there is no question that we have a great talent in technology. I was told repeatedly in Japan that one of the secrets of their success was their adjustment of skills developed in practicing the art of calligraphy to modern conditions. Could a people - who can write a whole *surah* of the Holy Book on a grain of rice - not succeed equally, when it comes to microelectronics?

In my younger days there used to be a saying that the Indian Muslims can not shine in the field of Accountancy. Contrast this with today, when almost all banking in the Middle East is run by Pakistanis. True enough, the Pakistanis are, by temperament, individualists - like the French<sup>12</sup> for whom personal "glory" was always the spur. No doubt wise governmental policy would recognise and enhance rather than hinder this natural trait. However, when outside Pakistan, Pakistanis are known more for working together and helping each other rather than for competitive individualism,<sup>13</sup> - they too display those characteristics of the Confucian ethics, which have distinguished the technologically successful (Pacific) nations of today.

In this context, I cannot overemphasise the value of Science and Technology in building national character through the qualities they engender - thoroughness, patience, pride in one's work, finesse, and, above all, tolerance and respect for opinions other than one's own.

As Allah has promised, He does not let the efforts of those who strive go waste.

اِنِّي لَا اُضَيِّعُ عَمَلَكُمْ مِنْ ذِكْرِ اَوْ اُنْثَى .

I am confident that once we succeed in firing our younger generation with a zeal for science, there is going to be no one stopping us. With Jamal Nasir I would like to say: "ارفع راسك يا اخي" "Raise your head in pride and self-esteem, my brother".

Let me end with the prayer: let no future historian record that, in the fifteenth century of the Hijra, scientific talent was there in Pakistan but there was a dearth of statesmen to marshal and nurture it.

## Appendix I

Professor Michael Moravcsik, of the University of Oregon, wrote to me recently that he had been in correspondence with the President of Pakistan for a number of years and had pointed out to him that Pakistan universities were not generating any new knowledge nor transmitting new knowledge to their students and that, in his view, Pakistani Science was "in terrible trouble". Giving three indicators of this, Moravcsik wrote to the President: "I am enclosing a copy of the study I presented to the conference in Islamabad concerning Islamic science. Although it was not the aim of that study, the information in it can be used to compare the time development of Pakistani science with that of other countries. You can see the Pakistani data in Figures 1 and 7, and I marked them red in your copy, so they stand out better. You need not be a trained mathematician to notice that while the curves of most countries rise - 40% on the average and sometimes even more substantially, during the period under study - the curves of Pakistan are level or even fall. I am not claiming that the number of scientific authors is the only indicator of scientific activity within a country. Nevertheless, the marked effect in those graphs causes one to pause.

"The second indicator is less statistical. I was the originator of and have maintained connection with the Physics Interviewing Project, a programme that aims at providing a comparative and relevant quality assessment of students from Asia who apply to U.S. and other graduate schools in physics for advanced education with financial aid. The programme personally interviews such students in many Asian countries, and provides a one-page assessment sheet on each student. In the Fall of 1983 this project interviewed some 170 students in Pakistan, Nepal, Bangladesh, Sri Lanka, Singapore, Indonesia, Malaysia, Thailand, the Philippines, Hong Kong, and South Korea. Using a particular type of indicator for the quality of students found in each country, a ranking of these eleven countries can be made. In this ranking Pakistan stands ninth out of the 11.

"The third indicator is perhaps even more subjective but, I believe, by no means less valid. In surveying the Pakistani scientific manpower, one is struck by its being overwhelmed by older people. In 1962, when I first came

in contact with Pakistani science, there was a large group of bright young men in the sciences, many still in the process of being educated at an advanced level, but most already showing talent and achievement. Many of them contributed to science significantly in the following years. Members of that generation today are in their mid-forties, some still productive, but the group, on the whole, is declining in its contribution to research, perhaps because of administrative preoccupations, perhaps just out of general tiredness. What is striking, however, is that there appears to be no comparative younger generation of scientists to take the place of this older group. This is particularly ominous, because it beclouds not only the diagnosis for the present but also the forecast for the future.

*"Furthermore, at least externally, there appears to be no realisation, or at least no admission, on the part of those who run Pakistani science policy that there is a problem. I find the quality of the science management in Pakistan today much too low, consisting of people with no personal experience in doing science, with no perception about the nature of science and its role in a country's development, and with no vision and no elan."*

## **Appendix II**

This is a quotation from "Science and the Making of the Modern World", by John Marks (Heinemann, 1983) in respect of how Japan built up its Science and Technology. This would repay careful study. It illustrates the steps needed to cultivate science and technology; we do not need to reinvent the wheel.

### **Science and technology in Japan since the Meiji restoration**

In 1603 Mutsushito, an emperor of the Meiji dynasty, regained supreme power in Japan after centuries of rule by the feudal Shoguns. This could be seen as a retreat into the past but in fact it led to the rapid growth of Japan as a technological power which has continued, almost unchecked, ever since.

For nearly 250 years before 1869 Japan had been a closed society - almost isolated from the rest of the world. This had been a deliberate policy designed to exclude European influence, particularly Christianity. A few Dutch trading posts were all that were permitted although some foreign books were imported after 1720. Then in the 19th century the growth of European power and influence (see Chapter 4.II) across the world began to affect Japan. In the 1850s Japan was virtually forced to conclude trading treaties first with America and then with Britain, Holland, Russia and France. These treaties led to much more trade with Europe and America which gradually undermined the traditional feudal structure of Japanese society.

When the emperor regained power in 1869 he represented those who wanted to reverse the isolation policy and open up Japan to Western influence. The emperor proclaimed that "Knowledge shall be sought throughout the world so as to strengthen the foundations of imperial rule".<sup>1</sup>

In this chapter we will describe how that precept was put into practice in the 19th and early 20th centuries and how, in very different circumstances, it is still important in Japan today.

## THE MEIJI RESTORATION AND SCIENCE AND TECHNOLOGY - 1869-1900

Once the decision had been taken to import Western science and technology, the Japanese government set about the task with characteristic thoroughness. They made detailed surveys of the engineering industries in Europe and America. Then they acted on a broad front. For the short term they imported foreign engineers and scientists; for the medium term they sent students abroad and set up colleges in Japan staffed by foreign lecturers; and for the long-term they set up universities and numerous research institutes. Throughout, the emphasis was on the practical application of existing knowledge. In the words of the Prime Minister Prince Ito in 1886:

The only way to maintain the nation's strength and to guarantee the welfare of our people in perpetuity is through the results of science. ... Nations will only prosper by applying science. ... If we wish to place our own country on a secure foundation, insure its future prosperity, and to make it the equal of the advanced nations, the best way to do it is to increase our knowledge and to waste no time in developing scientific research.<sup>2</sup>

### *The importance of new techniques*

The foundations for the industrial revolution in Japan were laid by the Engineering Ministry established in 1870. Hundreds of foreign engineers were employed to build railways and establish a telegraph network. Modern technology was imported to develop the mining industry and to establish factories for cotton spinning. Most of these foreign engineers were British, but some were from France and the other European countries. Many of these engineers were paid salaries which were four or five times greater than those paid to Japanese government ministers.

### *Technical education*

Great emphasis was placed on technical education and many foreign lecturers were employed in Japanese schools and colleges. They primarily taught practical subjects like engineering, agriculture, medicine and geology together with supporting basic subjects like mathematics, physics, chemistry and biology. They came primarily from Germany, Britain, France and America

(see Fig. 7.5.1) and taught in their native languages. Again they were often paid much more than native Japanese.

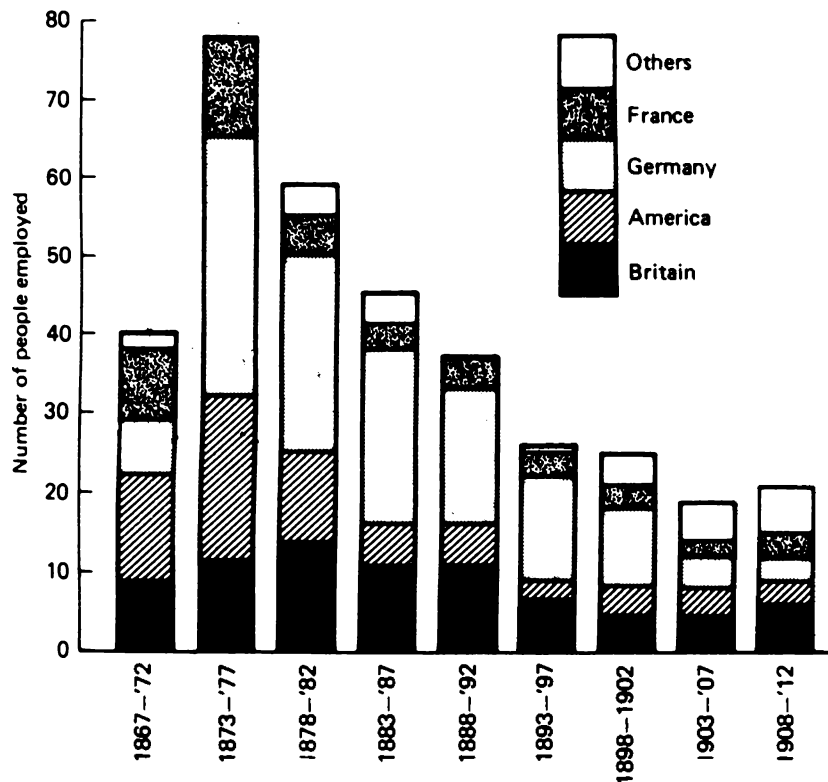


Fig. 7.5.1 Numbers of foreign lecturers in Japan, 1867-1912. Redrawn from Nakayama, S., "A Century's Progress in Japan's Science and Technology", in *Technical Japan*, vol. 1, part 1, 1968.

One particularly important development was the College of Engineering in Tokyo which was staffed mainly by British engineers and which began teaching in 1873. The aim of the College was "to train men who would be able to design and superintend the works which were necessary for Japan to carry on if she adopted Western methods."<sup>3</sup> The Prime Minister Prince Ito

later said"...that Japan can boast today of being able to undertake such industrial works as the construction of railways, telegraphs, telephones, shipbuilding, working of mines, and other manufacturing works entirely by the hands of Japanese engineers is mainly attributable to the College..."<sup>4</sup>

Many students were also sent abroad and later came back to teach the next generation of Japanese students.

*Universities, research institutes and scientific societies*

In the period from 1875 to 1900 the Japanese government established many of the same kinds of institutions which make up the scientific community in Europe and North America. The Imperial University of Tokyo was set up in 1877 and, a few years later, it absorbed the Tokyo College of Engineering. Similar universities were established at Kyoto in 1897 and Tohoku in 1911. Again the emphasis was on practical knowledge as can be seen from this extract from the charter of Tokyo University:

The aim of the Imperial University shall be to teach and study such sciences and practical arts as meet the demands of the State.<sup>5</sup>

The government also set up a number of research establishments during the years following the Meiji restoration. Examples include the Naval Hydrographic Division in 1871, the Tokyo Hygienic Laboratory in 1874, the Central Meteorological Observatory in 1875, the Geological Survey Bureau in 1878, the Electro-Technical Laboratory in 1891, the Institute for Research on Infectious Diseases and the Agricultural Experimental Station in 1892 and the Chemical Industrial Research Institute in 1900. Once again there is a clear emphasis on practical research.

Many scientific societies were also established in this period. The Tokyo Mathematical Society was founded in 1877 and later became the Japanese Mathematico-Physical Society. The Tokyo Chemical Society originated in 1878 and in the following year the Tokyo Academy of Sciences was founded, although initially natural scientists were in a minority on this body which was renamed the Imperial Academy of Sciences in 1906. Other societies were established for medicine in 1875, physical geology in 1879, pharmacology in

1881, meteorology and botany in 1882 and zoology in 1888. Societies for heavy engineering tended to be set up a little later - for mining in 1889, construction in 1886, electrical engineering in 1888 and mechanical engineering only in 1897.

Many of these societies have grown extremely rapidly since that time. See, for example, Fig. 7.5.2 which shows how the membership of the Japanese Mathematico-Physical Society increased from 1877 to 1945. From about 1888 onwards the growth was exponential with the number of members doubling roughly every ten years, except for a brief period during World War I. This growth is much more rapid than the growth in the population of Japan which has increased from about 36 million in 1875 to about 110 million today - a doubling time of about 60 years. And it is even faster than estimates of the growth of Western science where the doubling time is usually estimated as approximately 15 years (see Fig. 3.5.1, page 78 and Chapter 6.1)

This extremely rapid growth in the numbers of Japanese scientists took place in a number of stages as can be seen from Fig. 7.5.3 which shows the number of physicists active in Japan from 1860 to 1960. At first these were mainly foreign physicists together with a few foreign-trained Japanese (Group I); by about 1910 they had either left Japan, died or retired. These men trained a group of Japanese physicists (Group II) who from the 1890s onwards became the teachers of the first generation of Japanese physicists who were both trained in Japan and taught in Japanese. After this the physics community in Japan entered on a period of self-sustained growth (Groups III and IIIb) during which both the number of physics graduates (IIIa) and of postgraduate students (IIIb) doubled roughly every seven years.

## SCIENCE AND TECHNOLOGY IN JAPAN SINCE 1945

In 1945 Japan was a defeated nation - her productive capacity had fallen to only 10 per cent of previous levels and there was a threat of food shortages and epidemics. Since then Japan has become one of the most prosperous nations in the world. Science and technology have clearly been important in

this transformation but it is much less clear precisely how science and technology have influenced Japanese prosperity and what role the Japanese government has played in the rise of Japan as a major technological power. In this section we will try to illuminate these questions by describing some of the changes which have taken place since 1945.

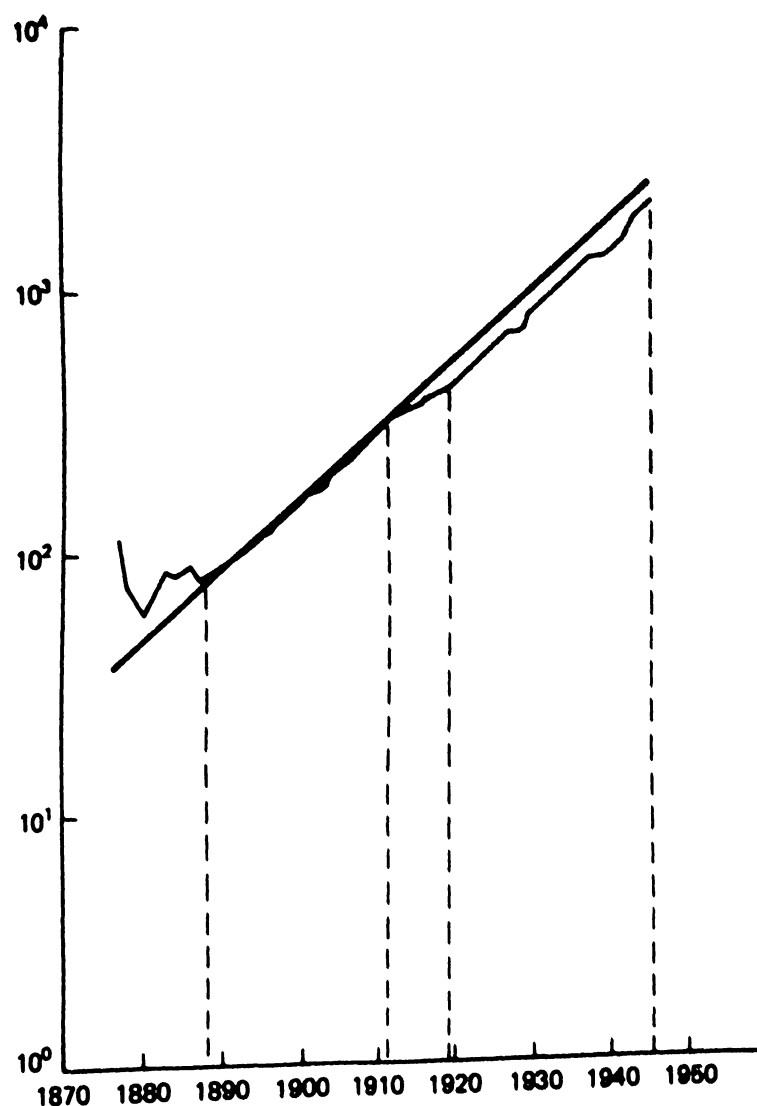


Fig. 7.5.2. Exponential growth in the membership of the Japanese Mathematico-Physics Society, 1877-1945 (logarithmic scale); the membership approximately doubled every ten years. Redrawn from Yagi, E., "The Statistical Analysis of the Growth of Physics in Japan" in Nakayama, S., Swain, D.L., and Yagi, E. (eds), *Science and Society in Modern Japan*, Cambridge, Mass: MIT Press, 1974.

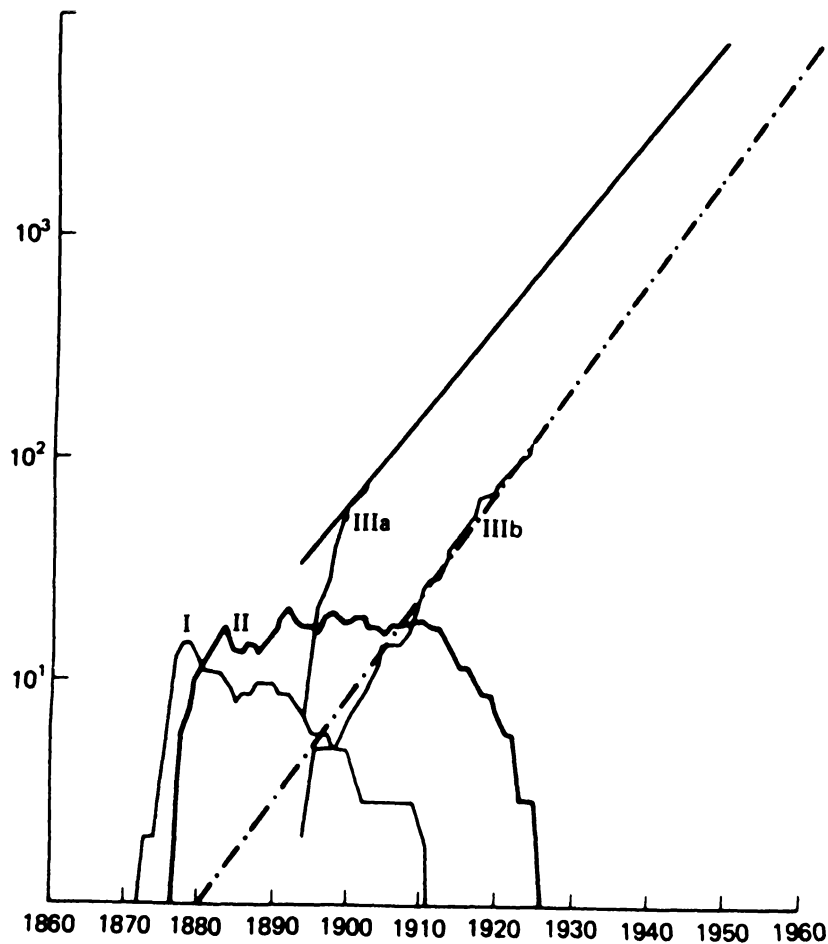


Fig. 7.5.3 Numbers of physicists in Japan, 1860-1960; I - Foreign or foreign-trained physicists, II - Japanese students of group I; III - Japanese physicists taught in Japanese, (a) graduates, (b) post-graduates continuing for D.Sc. Redrawn from Nakayama, S., Swain, D.L., and Yagi, E. (eds), *Science and Society in Modern Japan*, Cambridge, Mass: MIT Press, 1974.

#### *Post-war reconstruction, 1945-55*

In the early years the clear priority was to avert food shortages by the improvement of agriculture. Better strains of rice, more fertilisers and pesticides and improved agricultural machinery all led to greater output. Productivity also increased substantially which meant that more people were available to work in the growing industries of the 1960s.

As in the past, industries like mining and manufacturing were revived by the import of foreign technology. But by contrast with the 1930s, there was virtually no military or defence expenditure on science and technology. One result has been that, since 1945, private companies have provided by far the largest share of the resources devoted to research and development (see Table 7.3.4, page 381). But the government did control licenses for the import of foreign technology and set limits on the foreign ownership of Japanese firms. One important development was the import of quality control technology from the United States.

### *Economic growth*

In this period Japan's industries expanded rapidly. The production of household electrical goods such as TVs, radios and refrigerators grew very fast and major developments also took place in the transport industries - railways, shipbuilding and car manufacture - and in the production of artificial fibres. These changes also led to rapid growth in the production of iron and steel and in the output of the chemical industry. Towards the end of the 1960s the electronics industry also grew very rapidly and a considerable increase took place in expenditure on both research and development and on investment in equipment for the manufacture of semiconductors and integrated circuits.

In all these industries, great emphasis was put on the application of new techniques and many industrial research laboratories were established. The government also became more directly involved in research and development with the establishment of the Science and Technology Agency in 1956 and the Council for Science and Technology in 1959. These agencies have set up a number of research organisations and laboratories such as the Atomic Energy Research Institute in 1956 and the National Centre for Space Development in 1964. In addition, they have produced a series of reports on the state of science and technology in Japan which have considerably influenced government policies.

### *Foreign or Japanese technology? 1973 onwards*

Since the mid-1970s there has been a significant change in the major aims of science policy in Japan both in industry and in the government agencies. The emphasis is now much more on trying to develop specifically Japanese

technology rather than on the efficient application of technology imported from abroad.

The annual reviews published by the Council for Science and Technology identify some weaknesses in Japanese science but also clearly show that Japan is now one of the top six countries involved in large-scale scientific research and development - the other five are the Soviet Union, the USA, France, Britain and West Germany.

Fig. 7.5.4. shows, for the mid-1970s, the share of these six countries in the world's total GNP and total expenditure on research. The top six countries share about 65 per cent of world GNP but spend nearly 85 per cent of the total expenditure on research. Japan is third, after the USA and the Soviet Union, in both categories with just under 10 per cent of each of the totals. But Japan, like France, only spends about 2 per cent of its GNP on research compared with about 4.5 per cent in the Soviet Union and about 2.5 per cent for the USA, Britain and West Germany. Fig. 7.5.5 shows, for the same six countries, their share of the world's total number of research workers and total population. Together the six countries have about 75 per cent of the research workers but less than 20 per cent of the total population, while Japan is again third after the Soviet Union and the USA in numbers of research workers. More detailed analysis of the available statistics shows that, between the 1960s and the 1970s, Japan has roughly doubled its share of the current world technological capability and of the world potential for technological development. However, Japan still originates very little of the technology it uses.

In order to try to correct this imbalance, Japan is now attempting to foster genuine innovation in science and technology both by bringing together outstanding researchers and by investing heavily in specific projects such as the development of nuclear power - both fission and fusion; satellites for meteorology and communications; short take-off and landing aircraft; biotechnology; and an ambitious programme to develop the resources of the oceans.

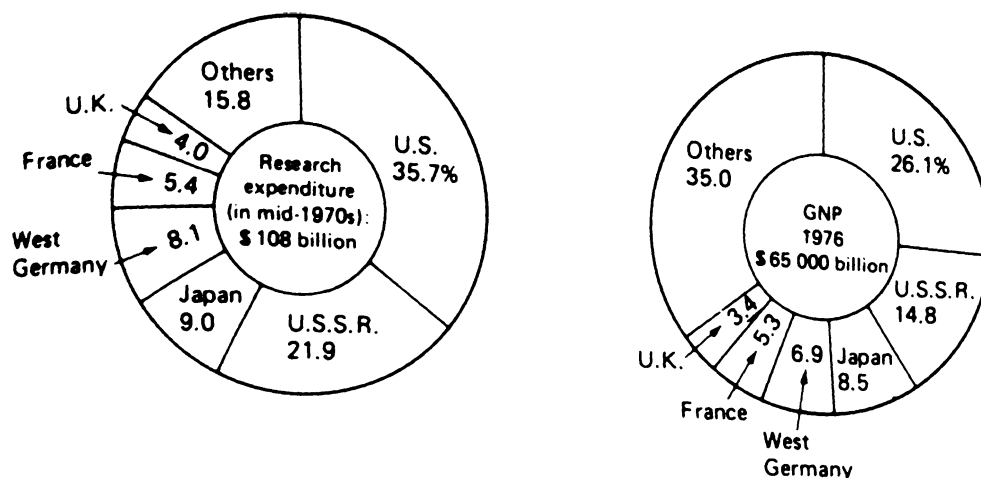


Fig. 7.5.4 Proportions of total world Gross National Product (GNP) and research expenditure in the mid-1970s. *From Science and Technology in Japan, vol. 1, no 1, January, 1982, Japanese Government Publication.*

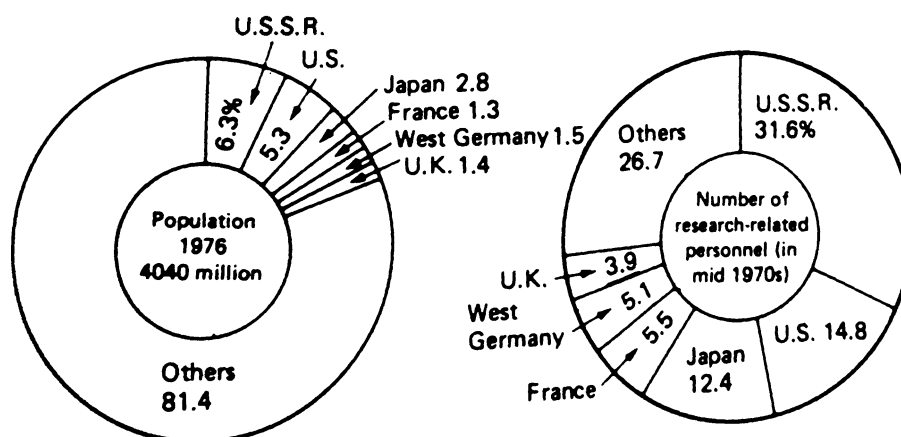


Fig. 7.5.5 Proportions of total world population and research workers in the mid-1970s. *From Science and Technology in Japan, vol. 1, no 1, January, 1982, Japanese Government Publication.*

Only time will tell whether these projects and policies really will make Japan, for the first time, a net exporter of science and technology.

Another and perhaps more important question remains about the remarkable growth in Japanese technological strength ever since the Meiji restoration and since 1945 in particular. Does Japan provide a model of technological development which other countries could follow? Or is the rise of Japan, in just over a hundred years, from a relatively poor agricultural and feudal country to one of the world's richest technological powers, due primarily to specific features of the Japanese character and social structure?

## REFERENCES

- 1 Fox, G., *Britain and Japan, 1858-1883*, (Oxford: Oxford University Press, 1969), p. 261; quoted in Brock, W.H., *The Japanese Connection*, British Journal for the History of Science, Vol. 14, No. 48, 1981, p. 229.
- 2 Brock, W.H., op. cit., p. 229.
- 3 Ibid., pp. 232-3.
- 4 Ibid., pp. 239.
- 5 Tuge, H. (ed.), *Historical Development of Science and Technology in Japan*, (Tokyo: Kokusai Bunka Shinkokai, 1968), p. 101.

## SUMMARY

- 1 In 1869, after centuries of isolation, Japan adopted a policy of rapid industrialisation.
- 2 Expert foreign engineers were recruited to introduce new techniques and to staff new colleges and universities; many research organisations and scientific societies were founded.
- 3 Heavy industries were developed from 1900 onwards and Japanese science and technology became increasingly devoted to military purposes culminating in war with China in 1937 and World War 2 in 1941-5.
- 4 Since 1945, the efficient application of imported science and technology has played a major part in Japan's emergence as one of the most

prosperous nations in the world.

- 5 The majority of Japan's investment in scientific research and development is made by private industry but the government is now attempting to foster genuine innovation in science and to develop specifically Japanese technology.

### Appendix III

Francis Giles provides one outside observer's assessment of Science in Islamic countries. Writing in the prestigious scientific journal, *Nature*, of 24 March 1983, he raises the question: "What is wrong with Muslim Science?" To it he gives this reply: "At its peak about one thousand years ago, the Muslim world made a remarkable contribution to science, notably mathematics and medicine. Baghdad in its heyday and southern Spain built universities to which thousands flocked: rulers surrounded themselves with scientists and artists. A spirit of freedom allowed Jews, Christians and Muslims to work side by side. Today all this is but a memory.

"Even the recent wealth provided by oil export makes relatively little difference..science policy and politics, much to the displeasure of many scientists, are closely linked in the Middle East. The region is dominated by dictatorships, benevolent or otherwise...further complicating any attempt to allow science to take root indigenously. Not surprisingly the brain drain to industrialized countries continues to debilitate intellectual life throughout the Middle East". It is harsh criticism, but much of it is factual and deserved, and with lessons for Pakistan.

The same issue of *Nature* contains an article on Research Manpower in Israel from which I quote: "The need for a substantial increase in the number of academically trained people to work in research and development is widely accepted. The National Council for Research and Development has urged that their country will need 86,700 such people in 1995, compared with 34,800 in 1974 - an increase of 150 percent". Compare the Israeli figure of 34,800 with around 45,000 researchers in all Islamic countries, including Pakistan \* (the population ratio is 1:200).

\* The figures are taken from the Secretariat Report presented to the first meeting of the *Islamic Conference on Science and Technology*, held in Islamabad in Pakistan in May 1983.

فَاعْتَبِرُوا يَا أُولِيَ الْبَصَارِ

"O, those with vision, take heed"

## Notes

- 1 There are some - regrettably even among the Muslims - who dismiss the advances made in the great days of Islamic Science - in Mathematics, in Physics, in Biology, in Chemistry and in Medicine - as a "mere continuation of Greek tradition". Even such men cannot gainsay the undoubted fact that through systematic observation and patient experimentation the Muslims were the first peoples to bequeath to the world the idea that science, in the end, is an empirical subject. (Thus, in Briffault's words: "The Greeks systematised, generalised, and theorised, but the patient ways of detailed and prolonged observation and experimental inquiry were altogether alien to the Greek temperament ... What we call science arose as a result of new methods of experiment, observation and measurement, which were introduced into Europe by the Arabs. [Modern] science is the most momentous contribution of the Islamic civilization ...". These thoughts are also echoed by George Sarton, the great historian of Science. "The main, as well as the least obvious, achievement of the Middle Ages was the creation of the experimental spirit and this was primarily due to the Muslims down to the 12th century"). This emphasis on empirical skills has meant that Muslims everywhere and in particular, those from Pakistan, India and Bangladesh, have always excelled in traditional craftsmanship.
- 2 For example, before we castigate the Council of Scientific and Industrial Research for not initiating research in Pharmaceutical Chemistry, let us not forget that our successive Governments appear to have decided during the 40 years of our existence that we will do no more than compound, pack and produce tablets from imported pharmaceutical chemicals. Even the indigenous manufacture of aspirin or vitamins (which was started a few years ago) was discontinued for lack of protection, normally to be expected as part of a Technology Building Policy (as, for example, pursued in India). The only occasion when the Council of Scientific and Industrial Research was truly given a mandate was during the 1965 war, when import of war chemicals was cut off. The chemists in the Council rose magnificently to the challenge. Every one expected that after the war, we would continue to produce all such chemicals in Pakistan. But a few months later, their import was resumed.
- 3 The same is true of most other countries of Eastern Europe, which exhibit a veneration for science which borders on the religious. In Sofia recently, I saw in the centre of the city the most prestigious site in the major square occupied by the Academy of Sciences (of which most research institutes of the country are part). I was told that the Academy of Sciences was founded by exiled Bulgarian scientists some 125 years ago while Bulgaria was still under Turkish rule and had not even acquired an independent status as a nation.
- 4 "In a field like plasma physics India has over 150 scientists while Pakistan has only 3. In laser physics the number of those working in Pakistan is

not more than 15 while India has over 200 laser physicists and China 2000. The number of active scientists in India exceeds that in Pakistan by a factor of eighty (although on population basis we are one eighth the size of India)". (Mujahid Kamran).

- 5 When we speak of bureaucracy's contempt for the scientist, let me recall a past Chairman of the Planning Commission, who had this to say to me when I requested housing for scientists: "Everybody in Karachi sleeps on footpaths. Why can't the scientist do the same?" And when I suggested that he might consult scientists in the planning of science based industries, he replied: "Why should I consult the scientists? I do not consult my cook to show me how to run my household". By what divine right he was heading the Planning Commission, he did not tell me.
- 6 It was this isolation which prompted me to propose the creation of the International Centre for Theoretical Physics so that physicists from developing countries need not make exiles of themselves in order to keep themselves abreast of newer developments of their subjects. This Centre belongs to two United Nations Agencies - IAEA and UNESCO; during 1985 alone, 57 Pakistani physicists were supported at the Centre (by grants from Italy or Sweden).
- 7 Examples from U.S.S.R. and Israel are merely illustrative.
- 8 To strengthen University Science, and to eliminate possible rivalry between universities and the Government Research Institutes, we must adopt the United States pattern where research institutes, even if they are federally financed, are always linked with universities. To take one example in my field, three of the major laboratories of the U.S. Department of Energy (the Brookhaven National, the Argonne National and the Los Alamos Laboratories) are operated on behalf of the Federal Atomic Energy Authority (and with federal funding) by consortia of U.S. universities.  
Why have the university linkages with institutes of an applied nature (in agriculture, medicine, health and other such fields) proved such a source of strength for U.S. science? The reasons are not far to seek.  
First, one of the indirect objectives of all such research institutes is, and should be, a wide dissemination of research skills within the community. There is no surer means of doing this than by linking such institutes with universities and letting postgraduate students go through them.  
Secondly, and reciprocally, the quantum of basic science every applied research laboratory needs for its health and vigour does not have to be created ab-initio within the laboratory. The linked university faculties automatically provide this.
- 9 Just after Josephson was awarded the Nobel Prize for Superconductivity, MITI decided there was a future in Josephson junctions for beating IBM in fast computer technology. Such decisions were not new for MITI which had systematically taken similar decisions in the past for microchips, for videocassettes and for microprocessors. Would it be too starry-eyed to propose that Pakistan should take a leaf out of Japan's (or South Korea's) book in the fields of microelectronics, biotechnology, fibreoptics and

energy and provide training to its *industrialists* and *entrepreneurs* so that they may invest in high technology areas?

- 10 In 1973, the then Pakistan Government, on my suggestion, requested the Islamic Summit in Lahore to sanction at least one Foundation for Science for Islam, equal in size to the Ford Foundation, with a capital of one billion dollars. The request was agreed to, in principle. It took eight years for further action; in 1981, such a Foundation was created but with just 50 million dollars promised instead of the one billion requested. Of this I believe only 6.5 millions have so far been contributed. It may have been more charitable not to have deceived ourselves by this creation.
- 11 The reason for this emphasis on Science has been beautifully spelled out by Huston Smith - a Christian writer: "In an age charged with supernaturalism, when miracles were accepted as the stock-in-trade of the most ordinary saint, Muhammed refused to traffic with human weakness and credulity. To miracle-hungry idolators seeking signs and portents he cut the issue clean: 'God has not sent me to work wonders; He has sent me to preach to you. My Lord be praised! Am I more than a man sent as an apostle?' From first to last he resisted every impulse to glamorise his own person. 'I never said that Allah's treasures are in my hand, that I knew the hidden things, or that I was an angel ... I am only a preacher of God's words, the bringer of God's message to mankind'. If signs be sought, let them be not of Muhammed's greatness but of God's, and for these one need only open one's eyes. The heavenly bodies holding their swift silent course in the vault of heaven, the incredible order of the universe, the rain that falls to relieve the parched earth, palms bending with golden fruit, ships that glide across the seas laden with goodness for man - can these be the handwork of gods of stone? What fools to cry for signs when creation harbours nothing else! In an age of credulity, Muhammed taught respect for the worlds' incontrovertible order which was to awaken Muslim science before Christian. Only one miracle he claimed, that of the Quran itself. That he by his own devices could have produced such truth - this was the one naturalistic hypothesis he could not accept".
- 12 One could consider the possibility of our creating a higher institution (for scientific and technological training and research) like the Ecole Polytechnique of Paris as an alternative to an MIT type of institution. The Ecole Polytechnique was founded by Napoleon; it emphasises Mathematics, Physics, Engineering, Economics, and, now, Biotechnology, at the highest level, just like the MIT. However, the major difference lies in the career prospects offered by the two types of institution. Those who are selected to join the Ecole Polytechnique (after a highly competitive national examination) are given a military commission from the first day of joining. This does not mean that they must necessarily serve the French Army; they can choose top civil positions in the French Technical Civil Service, they may become top bankers or occupy top level University Chairs. For a status conscious society, this guaranteed pattern of career prospects has secured for France its present Technological and Scientific lead in Europe.

- <sup>13</sup> I remember, for example, meeting the Venezuelan Minister of Finance, who spoke of a Pakistani Mafia, which, in his opinion, were so well knit that they ran the World Bank during the 1970s.

# Towards a Scientific Research and Development Policy for Pakistan

*Address at the XIIIth Meeting of the Pakistan National Science Council, Islamabad, 8-9 September 1970.*

## Introduction

Pakistan has few natural resources. Prospecting up to the present reveals that it possesses no metals, no minerals, very little oil. Our major resources are three: (1) natural gas; (2) rich alluvial soil, provided it can be irrigated in West Pakistan and protected from floods in East Pakistan; (3) abundant man-power, provided it is skilled. These skills include those in agriculture, scientific engineering, and mathematics. Highly skilled man-power is needed (a) for protecting the country's territorial integrity; (b) for ensuring agricultural plenty; (c) for all manufacturing – in fact for ensuring any sort of honourable existence for Pakistan in the modern world of competitive technology .

This note is not concerned with the acquisition of these skills at a middle level. This crucial requirement was the subject of a separate note. Here I shall be concerned with the apex of the scientific and technological profession – the elite of the scientific community. This elite could constitute one of the most important national assets if a coherent national policy harnessed their talents. This note is addressed both to the policy-makers and to the scientific community.

§ 1 There are three things wrong with Pakistan's research effort in science and technology:

- (i) The small absolute size of science in relation to the economy's technological needs and to the country's cultural sophistication;
- (ii) The neglected development of research in certain important spheres;
- (iii) The lack of contact with international science.

These shortcomings basically stem from the same cause: *Pakistan has never*

*had a coherent science policy.* The growth of science has come about more or less sporadically through the efforts of certain notable scientific entrepreneurs. Their efforts have not been correlated with state planning and administrative machinery.

## § 2 *Small absolute size of science*

Pakistan's scientific effort is located within government laboratories (provincial and central) and the universities. Even though some industries like textiles, fertilizers, machine tools, gas and oil-refining have reached the stage of maturity where they could support their own industrial research and development establishments, none have yet been started.

Assuming that total expenditure on research and development (provincial and central) is an index of its size, the National Science Council figures for all spending on scientific research during 1966-67 are as follows:

	CRORES OF RUPEES (1 crore rupees = $10^7$ rupees = 2 million dollars)
Industrial research <sup>1</sup>	1.92
Atomic energy research	1.94
Agricultural research <sup>2</sup>	1.80
Environmental sciences <sup>3</sup>	0.79
Medical and family planning research	0.29
Building and roads research	0.16
Research on irrigation and flood control	0.11
University research <sup>4</sup>	0.38
<i>Total</i>	7.39

<sup>1</sup> This is mainly conducted in the laboratories of the Pakistan Council of Scientific and Industrial Research (PCSIR). The figure includes 0.14 crores for the Central Testing Laboratories.

<sup>2</sup> This includes Central Cotton and Jute laboratories and all provincial laboratories and stations.

<sup>3</sup> This includes expenditure on geological survey, zoological survey and soil survey in Pakistan.

<sup>4</sup> Actual expenditure is probably lower. This figure represents 10% of total university science spending.

This represented 1/8 of one per cent of Pakistan's gross national product. In most advanced countries of the world the corresponding expenditure ranges between 2-3% of the GNP with 1% for developing countries like India, Korea, Formosa and Brazil. Another index of the size of science is the total number of active researchers in any country. Judged on this basis too, Pakistan stands among the lowest 25% of the countries of the world.

### *§ 3 Neglected development of the scientific effort*

At the present stage of its economic and technological development, Pakistan's research and development needs can be divided into the following categories:

#### *(a) Adaptive research needed to complement imported technology.*

At present Pakistan imports technical know-how, technical processes, plant and in some cases basic raw materials in the following fields:

- Most manufacturing and fuel refining industries;
- Telecommunications, transport and power (including atomic power);
- Medicine, pharmaceuticals and fertilizer manufacture.

By and large it would be unrealistic to hope that Pakistani science could soon compete with the enormous research and development effort which has gone into the developing of processes and know-how which the country imports. A wise science policy in these areas would attempt to channel the local effort - effort that would have to be massive to yield economic returns - towards a well co-ordinated, *adaptive*, *substitutive* and *complementing* role. (Lest any misunderstanding be created by the words "adaptive and complementing role", it is important to realise that it is this crucial type of supporting effort which for countries such as Japan - till recently importing most of their know-how - absorbed as much as about 1.55% of the GNP compared to our one-eighth of one per-cent).

#### *(b) New research and development in areas of interest to Pakistan only*

The world supermarket of available science and technology may be vast, but there are areas of concern to Pakistan where relevant development must be carried out in our own country. Some of these areas include:

- Soil and irrigation; flood and cyclone control;
- Local minerals - their exploration, extraction, beneficiation;
- Preventative and tropical medicine, including veterinary medicine;
- Local food and cash crops (jute, tea, cotton, millet, fodder) and industries based on these.

If we consider Pakistan's present applied research effort we notice that there has been some slight emphasis on the adaptive areas of industrial and atomic energy research. But support for research and development in areas where Pakistan cannot wholly draw upon the resources of world knowledge is simply derisory<sup>5</sup>.

(c) *Neglected university research*

Perhaps the most unfortunate example of a totally neglected sphere is university science. It is unbelievable but true that Pakistan has by and large no tradition of graduate school<sup>6</sup> training, no Ph.D.s are produced; almost all research training is foreign training. Unlike the rest of the world, it is not

<sup>5</sup> It is important to stress that the absolute spending even in these two spheres of industrial and atomic energy research is highly unsatisfactory on any world scale. In relation to the size of its atomic power programme, for example, Pakistan has perhaps the lowest spending rate on supporting research. It is the almost total neglect of the other fields that is being stressed in this paragraph.

<sup>6</sup> To take just one instance of this: the premier University of Pakistan - the Panjab University - in its one hundred years of existence has produced not a single Ph.D. in Mathematics. In Pakistan the "centre of excellence" has become current in speaking of university research schools. Unfortunately this usage somehow gives the impression that post-graduate research schools of *moderate* quality already exist and that some of these, if provided with further resources, could attain world class. This is just not so. In most universities, in most subjects, no post-graduate schools of any quality exist at all. I am pleading here for the academic and financial provision of normal post-graduate research facilities - not in every department, in every university but in most. This would necessitate doubling or trebling present staffs and providing funds to them for purchasing some decent teaching and research equipment. The hope could be that some of the funds for such post-graduate schools will be provided by the University Grants Commission and *more importantly* from the analogue of a National Science Foundation which we must create. These schools would give Ph.D. training, obviating for the most part the need for foreign post-graduate training.

considered part of a university teacher's assignment that (as a norm) he devotes half his time to teaching and half to research. This is partly a result of the 19th century educational system bequeathed to us by the British, where research was considered the task of a gifted amateur working in his spare time. Partly it is a consequence of the dismal financial weakness of our universities <sup>7</sup>, the non-existence of an independent, stable university grants system and the non-existence of anything corresponding to the National Science Foundation in the U.S.A. or its U.K. counter-part, the Science Research Council, which are central government organizations with charters to foster basic research by making available to university teachers individual grants for their research projects.

If we consider expenditures, Pakistan's twelve universities spend 0.38 crores on their research programmes. This is roughly one-twentieth of the total research effort. A comparison with the U.K. is instructive: out of a total of about 200 million pounds spent by the U.K. Government on civil research in 1966-67, 61 million pounds were directly spent by the universities for their research programmes – a ratio of one in four <sup>8</sup>. The total spending on basic research

<sup>7</sup> The Indian universities are apparently no better. It has been estimated by the Nobel Laureate Professor H. Bethe that if Indian universities started *normal graduate schools* on the US pattern every Indian scholar at present in the US – and their numbers exceed five thousand – could be absorbed into the higher educational system of the country, with incalculable benefits to the quality of Indian education.

<sup>8</sup> The total U.K. spending on research and development was of the order of 700 million pounds; of this 500 million pounds were spent by industry in its own establishments. The *Government* spending was shared out as follows:

	<i>Million Pounds</i>	49.0
University research		44.7
Science Research Council (basic research)		53.0
Atomic energy		19.4
Medicine		14.2
Agriculture and forestry		14.1
Industrial and testing establishments		<u>11.5</u>
Environmental research		205.9
<i>Total</i>		

Defence science – large fractions of which benefit civilian research also – has not been taken into account in these figures.

was still higher - something of the order of 100 million pounds.

If there is one reform which I consider absolutely basic to the entire future of scientific research in Pakistan, it is the massive provision for research - and its separate funding - in the universities. Without this reform, Pakistan science can have no strength, no backbone, no real future. We shall come back to this later.

#### § 4 *Wrong location of our research effort*

Besides small size and one-sided development, the third weakness of Pakistani science is its wrong location. Historically we inherited the U.K. pattern for the organization of scientific research. This pattern emphasized the role of central government establishments (organized like executive departments) for industrial research as well as for research in other fields. Contrasting with this is the U.S. pattern where industrial research is developed within each industry or groups of industries, while all other research is conducted in institutes which may be federally financed but are almost always linked with universities. It is as well to recall that most state universities in the U.S. started as agricultural colleges and agricultural research establishments and that three of the major laboratories of the U.S. Atomic Energy Commission, the Brookhaven National, the Argonne National and the Los Alamos Laboratories<sup>9</sup>, are operated on behalf of Atomic Energy Commission (and with Commission funding) by consortia of U.S. universities<sup>10</sup>.

The U.K. pattern of Government-run research institutes unlinked with the country's educational system held until recently also in the U.S.S.R. After the Second World War, India, Australia, and Pakistan adopted this system, just

<sup>9</sup> This is the laboratory where atomic weapons were first developed. Classified parts of the laboratory still continue this research.

<sup>10</sup> In connection with the proposal to set up a World University under the United Nations' auspices, it was recently proposed that a World Federation of Institutes of Advanced Study outside of the normal university system should be set up to be linked with the U.N. World University. It proved impossible to identify more than half a dozen first-rate institutes (even of applied nature) in the U.S. which were not part of one university or another. This illustrates the strength of the university system in the United States.

about the time that its limitations were beginning to be realized both in the U.K. and in the U.S.S.R., where at present this pattern is in the process of being abolished.

We shall consider industrial research separately later. The arguments for industry carrying out its own research and development, if its size warrants this, are so strong that one does not have to argue in favour of the U.S. pattern in this respect. But why has the university linkage of institutes of an applied nature in agriculture, medicine, atomic energy and other such fields proved a source of strength for U.S. science? The reasons are not far to seek:

- (1) One of the indirect objectives of all such institutes is, and should be, a wide dissemination of research skills within the community. There is no surer means of doing this than linking such institutes with universities and letting large numbers of post-graduate students go through them.
- (2) One of the terrible problems most research institutes face is the aging of their research staffs. By and large, pursuit of research needs young and vigorous men. In a university atmosphere the older research men automatically take on more and more of the teaching tasks for which age and experience make them particularly suited.
- (3) The quantum of basic science every applied research laboratory needs for its health and vigour does not have to be created ab initio within the laboratory. The university faculties automatically provide this.

To conclude this section one may mention one final aspect of the wrong location of our effort. Most research establishments - certainly in the provincial sphere - are sited within the normal government department structure. Research does not thrive in an atmosphere where the command structure, career opportunities, and procedures for acquiring needed equipment and facilities are those of a government executive department.

## **§ 5 Isolation**

One further weakness of Pakistani science is its isolation. Pakistan is located

physically far from sources of scientific ideas, literature and equipment. Isolation in science leads to stagnation and stagnation to intellectual death. Nowhere else, perhaps, does the lack of a concerted science policy make itself so immediately felt as in the rapid waning of the enthusiasm, freshness and spontaneity of Pakistani scientists soon after they join our establishments.

## § 6 Remedial measures - some guidelines

It is heartening that for the first time in the country's history the scientific community has been invited to help in defining a coherent science policy and, in particular, in identifying areas where science is, and can be, immediately relevant to the development of Pakistan and its transformation into a *technologically modern and scientifically literate society*. This task is being carried out by a number of study groups which one hopes will acquire continuing life as national committees in their respective scientific and technological disciplines. From their work will emerge recommendations on *the size of science, its location*, and the new research centre needed to be set up in the neglected areas. Some general considerations in this regard are listed in this section. These are, of course, simply guidelines to stimulate discussion.

### 6.1 *The size of science*

There can be small variations, but overall there is no escaping international norms. *The Pakistan Government and industry must commit themselves to increasing their spending on science in universities, in agriculture, medicine, water development, power development, and manufacturing to something like one per cent of the G.N.P. if the country desires to transform itself into a technologically modern one.* The National Science Council has requested the Planning Commission for an increase in annual *government* allocation to science from its present Rs. 7-8 crores level to a figure of something like Rs. 28 crores (one third of one per cent of the Gross National Product). This is a modest request. Without this order of spending one may as well write off any massive impact of local science either in an adaptive or innovative capacity. The requested funds (representing both development and recurring expenditure) will be spent on strengthening existing effort and in creating new research establishments, plans for which are being drawn up by national committees appointed by the National Science Council. These will be scrutinized by the Council and presented to the Planning Commission. With their acceptance and

implementation one hopes a new era for science will begin.

## 6.2 *Mission-oriented research*

Overall, the bulk of these funds - presumably some two-thirds - may be devoted to mission-oriented applied research, the rest (annually around 9 crores) to university science. It is important, in order that the country obtain the expected (manifold) return on funds thus employed, that the structure of Pakistan science and its location *maximizes the benefits accruing to the economy*.

### (a) *Industrial research*

The problem of structure, size and location of research establishments arises most crucially in respect of industrial research. At present almost all research and development effort is concentrated in multi-functional government-run laboratories with no sponsorship - and in most cases no visible interest - from industry in the results of the investigations. This situation must change.

I personally believe that the time has come when the more mature of Pakistan's industries - textiles, paper, sugar, cement, fertilizers, gas, fuel refining, telecommunications and some of the metallurgical industries - should support their own research and development establishments of moderate size, the units in each industry either acting individually or in concert. To provide the gentle persuasion so necessary in our country, there will be need for a *statutory levy*<sup>11</sup> (depending on size) in addition to government funds for commissioning the projected single-purpose research establishments located alongside each industry. One may envisage that in the immediate future these establishments would be government-run on behalf of the industries concerned and employ some of the trained staff presently working at the multi-functional laboratories of the Council of Scientific and Industrial Research. The important point being made is that these establishments should be (a) single purpose and (b) located within the relevant industry.

<sup>11</sup> I do not know the rates of levy for research institutions in the United Kingdom. For related activity - apprenticeships and industrial training schemes - this levy ranges from 0.33% to 2.5% of the pay-roll depending on the type of industry concerned.

One may go right down the line to consider the needs of even smaller industries, like chassis-building or sports-goods or cutlery, and envisage following something like the present United Kingdom (and Western European) practice of setting up (government-sponsored and industry-financed) *co-operative industrial research institutions*. In the United Kingdom there are at present some two dozen such government-sponsored institutions for research and development for baking and flour milling, brushes, cast-iron, cutlery and files, drop forging, gelatin and glue, glass, paints, springs, shoes, timber, lace, hosiery, welding and wool. These institutions employ six thousand scientists, spend some 13 million pounds and serve the needs of industries with a turnover of about 40,000 million pounds.

The pattern for industrial research which is being advocated here is thus somewhat different from the one we have so far pursued. *Different* is perhaps not the right word - the new pattern is a logical development of our past practice necessitated by our growing maturity. In this pattern the emphasis is on statutory participation by industry, with Government sponsorship of the research development institutions. Newer institutions would develop as new industry comes into existence and *not before*. Some of these institutions would naturally be formed from the present divisions of the Council of Scientific and Industrial Research Laboratories. Others would be new. The Council would remain the overall organizing body for all the institutions and, of course, also run those of its present establishments unaffected by the changes suggested.

#### (b) *Agriculture*

The other field where research utilization has presented a problem is the field of agriculture. There is need for a closer association of the agricultural research establishments, the agricultural advisory services, the extension workers and the farming community - a very difficult task, but one without which the research effort is simply wasted. The point I am trying to make is that the ensuring of research utilization is and should be as much a scientist's worry as the actual conduct of research and that his involvement with this task should be welcomed, encouraged and solicited. This is not something hitherto accepted as a scientist's mandate in a developed country; however, it is imperative in our context.

(c) *Irrigation, power, flood control, communications, telecommunications*  
These are areas of public investment and control. *I hope the principle is accepted that in future no technical corporation above a certain size and sophistication should come into existence without a statutory research and development establishment for it being sanctioned at the same time.* It is hard to understand how, for example, a nation supporting the largest irrigation system in the world could have neglected research in this field to such an extent that for advice on the salinity problem it needed help from the United States. And it is even harder to understand why after such a harrowing experience the nation can still be so unmindful of the need for a continuing massive effort in this regard.

### 6.3 *The universities*

It is imperative that the universities place emphasis on developing graduate schools for research training within Pakistan. To help in this and to sponsor the universities' research effort in basic sciences it is essential that an analogue of the National Science Council in the United States or the Science Research Council in the United Kingdom be created to make post-graduate research training awards, to give research fellowships and to make grants for purchases of equipment. As an example of the type of organization we need, the constitution of the U.K. Science Research Council is reproduced and its operation through standing national committees in each scientific discipline spelt out in the Appendix.

### 6.4 *Linkages of universities and research establishments*

I have already made a plea for the forging of closer links between our universities and research establishments on the U.S. pattern. Concretely one may envisage, for example, that the *atomic energy centres, the agricultural research institutes, the medical research centres and health laboratories* at present outside the university system will become part of it (even though they continue to be financed as now) and be integrated with universities in their neighbourhood. The same should apply to those divisions of the laboratories of the Council of Scientific and Industrial Research which are engaged in basic research. A suggestion that the Pakistan Institute of Nuclear Science and Technology (PINSTECH) should become part of Islamabad University (barring some special testing and other sections) was made by the Atomic Energy

Commission itself. This suggestion must be immediately accepted to avoid the university's essentially duplicating the costly facilities of PINSTECH in the same town and for the same body of scholars. Likewise the National Institute of Health, Islamabad, could become part of the Medical Faculty of the Federal University. The same would go for the new research establishments which are to be created.

I have no illusions that this forging of links <sup>12</sup> between institutes and universities is going to be at all easy, particularly when different departments and councils are paying for them. But it is so very crucial in a poor country such as Pakistan to save scarce manpower and other resources. It will certainly not be accomplished if the universities themselves do not develop strength through a stable and ampler funding and also rethink their role in our society, getting rid in the process of some of their currently inhibiting and academically constricting organizational patterns and practices. This includes the slow-moving, traditional conservatively oriented Boards of Studies, Academic Councils and Syndicates – which are wholly incapable of dealing with the autonomous and semi-autonomous Institutes we envisage situated on University Campuses.

### 6.5 *Ending of isolation*

There is a need for a comprehensive policy and for funds (particularly in foreign exchange) to end the isolation of Pakistani science from world science. There is a need for liberalization of leave measures, a need for funding of frequent

<sup>12</sup> I have in mind the types of privileges universities in the U.S.S.R., for example, accord to the Institutes of the Academy of Sciences which are linked with them. These are privileges which some of our Pakistani universities have felt reluctant to accord to the research establishments which wished to link with them in the past. The senior staffs of the Academy Institutes in the U.S.S.R. receive the appropriate titles of Professor, Reader, etc., or their equivalent from the universities they are linked with; they prepare post-graduates for research degrees in their institutes; on their side the universities call upon them for organizing and giving undergraduate lecture courses and instruction wherever necessary. These are the minimum reciprocal demands and privileges. More effective is the U.S. pattern where most research establishments function simply from within as university centres of faculties, notwithstanding their separate sources of funding. This is the pattern I would favour.

visits abroad, and a need for liberality and simplicity in the importation of literature and equipment. Pakistan must be one of the few countries in the world where attendance at a Scientific Conference abroad routinely needs permission from one provincial and three central Ministries. There is a growing movement sponsored by the World Bank, the United Nations Development Fund, United Nations Agencies and the leading scientific Foundations (Ford and Rockefeller) to create international centres for applied and pure research in those developing countries willing to host such institutes. A multi-campus World University - sponsored by the United Nations Organization - is coming. It is imperative that a well thought-out national plan should be drawn up immediately to try to secure the location of as many as possible of these world institutes within Pakistan. There is no relatively low-cost measure as potent as this for raising the quality of Pakistani Science.

### *§ 7 Administrative Organization of Pakistani Science*

For carrying through these and other recommendations, and particularly for creating the new research establishments, there is need for a fresh examination of the organizational structure of science in Pakistan. At present this structure is weak and diffuse. There are the Central Councils for Research in Atomic Energy (PAEC), Industry (PCSIR), Agriculture, Medicine, Irrigation, and Building and Works. These Councils possess limited mandates, extending either to the management of central Government laboratories under their control or to the award of tiny research grants. In addition there are provincial research establishments run by the Government Administrative Department whose activities are, by and large, uncoordinated with the Central Research Councils. There is in any case no council for the award of fellowships and research grants to universities analogous to the U.K. Science Research Council, no council for natural resources and the environment. In thinking of the future organizational set up, historical continuity might argue in favour of retaining the Council structure, but at the same time making each fully and truly representative of *all* scientific effort within its sphere, *whether provincial or central*.

If the Council pattern (augmented by at least two new councils, one for

environmental sciences and natural resources, the other for universities and basic research) remains the pattern for our science organization, the National Science Council (a more or less moribund entity at present which comes to life two or three times a year for its meetings) would need a revamped charter charging it with a general advisory role on the application of science and technology to development. In this capacity it would work in conjunction with the Planning Commission. In respect of its other task of strengthening science itself, it would itself act as the *Planning Commission for Science*. It would fix priorities, and make allocations of total funds available in the light of the claims of the various councils. It would also have the tasks of international liaison and of a concerted training of high-level manpower.

Finally, since the rules of administrative procedure in Pakistan demand that any Governmental corporation or organisation must function through a ministry, it seems imperative that the Ministry of Science and Technology, including its Secretaryship, be manned by scientists. I would envisage the Chairman of the National Science Council acting as Secretary to the Government for Scientific Affairs.

I fully realize that there are other equally viable patterns which one may devise for the organization of science. The one suggested above has the, perhaps debatable, merit of historical continuity.

I have not said very much in this note regarding the service conditions of the scientific profession. One aspect of the international character of science is that its norms are also international, whether they refer to the expenditure per scientist or to the service conditions under which his work can flourish. This must always be remembered if we expect internationally normed returns on the money spent on science in Pakistan.

## Summary

By and large, three categories of research and development establishments (in addition to direct University Institutes) have been suggested, the respective

councils being charged with the tasks of setting these up where necessary; of financing, running, or coordinating their operations. Given this pattern, one would hope that all Institutes existing or to be set up would find affiliation either with (A) a University (B) or an Industry (C) or with a Technical Corporation.

(A) *Category One: Research institutes linked with the university system.*  
This may include:

- (a) Agricultural research institutes linked with the complex of the Agricultural Universities of Pakistan for research on food (wheat, maize, rice, tea) and cash crops (jute, cotton, tea, tobacco) as well as institutes for soil and fertiliser research. Several of these exist already and merely need strengthening.
- (b) Medical research institutes and centres to operate in conjunction with the teaching hospitals, on tuberculosis, infectious diseases, nutrition, public health, population control, immunology, veterinary and other diseases.
- (c) Atomic energy centres linked with the local universities of Science & Engineering as suggested in the text; minerals institutes in association with the colleges of mineral technology and so on.

(B) *Category Two: Cooperative industrial research and development institutions*

Government sponsored but located within the complex of industries; for example in jute (located, for example, at the jute industry centre of Narayanganj), cotton textiles (Lyallpur and Karachi), wool, glass and ceramics, leather, cement, pharmaceuticals, cutlery, sports goods (Sialkot), food processing, packaging, paper and board, carpet-weaving, lace, gelatin and glue, paints, welding, cast-iron, machine tools, timber etc. Embryos of a number of these institutions already exist; there is, however, a need for strengthening and reorganization.

(C) *Category Three: Development and research cells and institutes*  
These were set up in conjunction with public technical corporations (with

cross-links with universities of engineering and technology). Examples include the hydrocarbon fuel industry, the ship-building industry, railway engineering, telecommunications, flood control, hydrology and land reclamation. Again a number of research and development establishments in these areas already exist but there is need for their strengthening. As emphasised in the text, there should be a statutory obligation on all public technical corporations above a certain size to create development and research cells or institutes within their structure. For example, the Steel Corporation of Pakistan which has been charged with the task of creating a steel manufacturing industry might at the outset set aside (statutorily) a percentage of its spending - around one percent perhaps - to create a development, training and research cell.

## Appendix

### Structure of the United Kingdom Science Research Council (for Basic Sciences) From the Official Reports of the Council

#### *The Science Research Council*

The Science Research Council (SRC) was created with the following functions:

"The carrying out of scientific research, the facilitating, encouragement and support of scientific research by other bodies or persons of any description of bodies or persons, and of instruction in the sciences and technology, and the dissemination of knowledge in the sciences and technology".

#### *Scope and constitution*

The purpose of the SRC is to provide support and facilities for fundamental and applied scientific research in universities and technical colleges and similar institutions. This is done by means of *research grants* and *training awards* (studentships and fellowships) and by providing, in its own establishments, *national research facilities which are corporately available for use by universities and similar institutions.*

The gross expenditure of the Council in 1968/1969 was 42 million pounds. Of this, 5 million pounds were spent on postgraduate awards and fellowships, 11 million pounds on the U.K. contribution towards C.E.R.N. and E.S.R.O., 7 million pounds on grants to universities and other bodies and the rest on the research establishments run by the Council for use by the universities.

### *Research grants*

The principal purpose served by research grants is to give help to research workers in universities and similar institutions in initiating research projects. The projects must be of merit and of timeliness and promise, this being widely interpreted and judged by the applicant's scientific peers who constitute the Committees and Boards.

Support is normally given by grants for approved projects, providing for staff, equipment, essential travel and other services.

### *Post-graduate training awards: summary*

Research Studentships are to provide for the maintenance of students whilst they are being trained in the methods of research. These cover about 16% of numbers graduating.

Research Fellowships are for promising young research workers who have completed the normal course of post-graduate research training, have shown a special aptitude for original and independent research and appear likely to benefit substantially from an opportunity to develop this aptitude further. The number of these fellowships during 1968-69 was 254.

## **Research Grants Scheme**

### *Policy*

It is the aim of the Science Research Council to provide financial help for research workers - usually in universities, colleges and similar institutions - to initiate and develop projects and ideas in science and technology.

*Subjects*

The Council is able to give grants to support researchers in astronomy, biology, chemistry, mathematics, nuclear physics, other physics, space sciences and in the sciences between and adjoining these, including, for example, biochemistry, fundamental psychology and behaviour, computing science, statistics and operational research, cybernetics and ergonomics, and also in engineering, including aeronautical, chemical, civil, electrical, mechanical production and systems engineering, and in metallurgical, polymer and material science.

Application for assistance in research in subjects in which the Agricultural Research Council, the Medical Research Council, the Natural Environment Research Council, the Office for Scientific and Technical Information and the Social Science Research Council are directly interested should be made to the appropriate body.

*Purpose of grant*

The Council will make grants for a stated period for applicants of acknowledged standing to initiate and develop a specific investigation of timeliness and promise in which they will be personally engaged.

The grants may support work by, or directed by, individuals and may enable investigators to:

- (a) employ additional scientific, laboratory, technical or other assistants;
- (b) invite senior scientists of distinction in other research schools in this country or abroad to the investigator's institution as Senior Visiting Fellows;
- (c) visit centres of excellence abroad and in the U.K.;
- (d) purchase special pieces of scientific apparatus;
- (e) provide materials and services including travel especially needed for research on a scale which the institution is unable to supply.

*Duration of grant*

A grant normally provides for the initiation or special development of research during a specified period, normally from one to three years.

The Council is, however, willing to provide financial support, in exceptional cases, for longer periods of three to eight years and, exceptionally, for longer periods.

Near the end of the quinquennium the S.R.C. will consider with the institution whether, in the light of its scientific worth and its cost, the work supported should be assimilated by the institution into its normal work, or be shared by the S.R.C. and the institution, or whether the cost should fall on the S.R.C.

*Operation of the Council*

The Council operates through a number of Boards consisting almost entirely of university professors. The Boards include:

- a) The Astronomy, Space and Radio Board;
- b) The Nuclear Physics Board with Panels on Nuclear Structure, Theoretical Physics, Nuclear Physics, Laboratories and Bubble Chamber Film Analysis;
- c) The University Science and Technology Board with Committees on Aeronautical and Civil Engineering, Computing, Biological Sciences, Chemical Engineering, Chemistry, Control Engineering, Electrical and System Engineering, Enzyme Chemistry, Mathematics, Metallurgy and Materials, Neutron Beam Research, Physics and Polymer Sciences.

# A Note on the Structural Changes in Pakistan's Educational System

*Summer 1969*

## 1. Quantity

When one considers Pakistan's literacy rate of 20%, its present enrolment rate at primary level of no more than 45% and, more significantly for the future, the 2.5% of the GNP we presently spend on education (compared to 5% in UAR, 5.9% in Ceylon and 7.2% in Japan), one is filled with unease. This note is not concerned, however, with the literacy rates, nor with curriculum content, but rather with changes required in the *structural pattern* of the educational system. These structural changes are basic to any reform. They have been identified and recommended by countless commissions; their implementation, however, has been impeded by bureaucratic resistance, especially departmental jurisdictional disputes - an impediment which Martial Law can dispose of.

## 2. Immediate Objectives

*For purposes of this note*, I shall emphasise two immediate objectives for the educational system:

- (a) the conscious creation of a feeling of Pakistani nationhood through the educational process;
- (b) the creation of skilled employable manpower, capable of building a modern nation.

### 3. Two Systems of Education Rather Than One

After a period of compulsory education, all modern societies provide two parallel educational systems. For simplicity I shall use the present British terminology which designates these two systems as:

- (a) *The System of Professional Further Education*, comprising technical, vocational, agricultural and commercial courses.
- (b) *The System of Higher Education*, comprising university level courses in the arts, sciences, higher engineering and medicine.

*The major structural failing of Pakistan's educational system is that no credible professional education system was ever created.*

It is true that a half-hearted system of polytechnics, industrial training and vocational schools has been built up in recent years. Unfortunately, it is grossly inadequate on the following counts:

- (a) After the lower secondary stage (to age fifteen) the proportion of those pursuing the two British systems is roughly 50:50 (see Table appended). In Pakistan, the proportion of those in (general) higher education to those in professional further education is 90:10. This preponderance of the technologically unskilled is the basic cause of our educated unemployed, their unrest, and the nation's technological backwardness. Our major task is to change this 90:10 ratio to something like 50:50. *The magnitude of this task and the need for a concerted crash programme to achieve it has never been appreciated.*
- (b) The professional education system in Pakistan is run by no less than six Government agencies (including the Departments of Education, Labour, Industry) with a "multiplicity of uncoordinated institutions and programmes - national, bilateral, multinational, private". \* There is no

\* Report on Technical Vocational and Industrial Training by Dr. R.M. Lyman, 1 April 1969, presented to the National Commission on Manpower and Education.

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After a period of compulsory education, all modern societies provide two parallel educational systems. For simplicity I shall use the present British terminology which designates these two systems as:

- (a) *The System of Professional Further Education*, comprising technical, vocational, agricultural and commercial courses.
- (b) *The System of Higher Education*, comprising university level courses in the arts, sciences, higher engineering and medicine.

*The major structural failing of Pakistan's educational system is that no credible professional education system was ever created.*

It is true that a half-hearted system of polytechnics, industrial training and vocational schools has been built up in recent years. Unfortunately, it is grossly inadequate on the following counts:

- (a) After the lower secondary stage (to age fifteen) the proportion of those pursuing the two British systems is roughly 50:50 (see Table appended). In Pakistan, the proportion of those in (general) higher education to those in professional further education is 90:10. This preponderance of the technologically unskilled is the basic cause of our educated unemployed, their unrest, and the nation's technological backwardness. Our major task is to change this 90:10 ratio to something like 50:50. *The magnitude of this task and the need for a concerted crash programme to achieve it has never been appreciated.*
- (b) The professional education system in Pakistan is run by no less than six Government agencies (including the Departments of Education, Labour, Industry) with a "multiplicity of uncoordinated institutions and programmes - national, bilateral, multinational, private". \* There is no

\* Report on Technical Vocational and Industrial Training by Dr. R.M. Lyman, 1 April 1969, presented to the National Commission on Manpower and Education.

single organisation at the centre or in the provinces with overall responsibility for it; naturally, there are no uniform practices or standards.

- (c) Since there is no single authority responsible, there is no national standard to measure achievement, no national certificate, no nationally accepted gradations, no cross-links between the two systems by which an interchange at various levels may be provided. The result is predictably a lack of prestige, a lack of recognition by employers - including the Government - of the worth of the products of the professional system
- (d) With divided responsibility, no concerted attempt has ever been made to reduce the shortage of qualified teachers and instructors. (Experience shows that the only consistent source of good instructors has been the armed services, but no systematic attempt has ever been made to tap this source).

#### **4 . Recommendations**

- (a) One single Technical, Vocational Education Authority with wide powers must be created immediately to bring some order to the present chaos and to plan with a sense of urgency for the future.
- (b) The Authority's first task will be to bring a *measure of prestige to this second system of education*. It will need to give serious consideration to the institution of National Certificates - or, what I would prefer, it may, in the matter of awards and their nomenclature, decide (for the present) to identify these with the awards of the other well-known system of education prevalent and respected in the country. What I have in mind is this. Parallel with the present liberal system of education in arts and sciences we create a second - the professional. Each award, the middle school, the matriculation, the intermediate, the B.A. (or B.Sc.) - may be obtained either after the present "liberal" courses in arts or sciences, as

now, or after technical,\* agricultural, or commercial courses - from a polytechnic, an agricultural or a commercial school. So far as job opportunities in administrative services are concerned all B.A.s (general, technical, commercial), *all* intermediates (general, technical, commercial), *all* matriculates of whatever variety would count as equivalent. Only thus will the exclusive hold on the public mind of the present prestigious "liberal" system of education be broken. (By adding new technical, agricultural or commercial streams to the present high schools or colleges, and thus making them "comprehensive", one may also obviate the necessity of a vast new building programme. Furthermore, common nomenclature will inevitably work towards giving a more *basic* slant to the professional studies, to their great advantage).

- (c) I have placed little emphasis on manpower projections for Pakistan or on figures that sound the alarm about the excessive cost of education. With the present level of 2.5% of the GNP spent on education and with no second system of education in existence, I feel one can reasonably ignore for the immediate future worry on this score. My personal preference would be to see the GNP percentage spent on education raised to 5% - with 2% of the new expenditure going to the creation of the second system and 0.5% on improving the present system.
- (d) In making these recommendations one will be accused of diluting the strength of academic awards - particularly the university bachelor's degree. I fully accept this. Let us be very clear. Our B.A. never compared with the British B.A. - we take it at the same age as the British Secondary School Advanced Level examination; its analogue always was the American B.A. - comparatively a rather feeble

\*Some further changes in nomenclature will of course be necessary. Thus the present B.Sc. in engineering which is normally taken three to four years after a first class intermediate science - i.e., after 15 or 16 years of schooling - would logically - and in accordance with the U.S. pattern - be redesignated as M.S. (Engineering) and so on.

attainment (the real American thrust always came *after* the B.A. stage, at the post-graduate level). In a democratic society like ours, the drive towards acquiring a university degree is absolutely irresistible. I feel we should accept this, as indeed the British have begun to do. It is not well known, but the apex of the British Further (Technical-Vocational) Educational System has recently been reconstituted; a Council for National Academic Awards has been created to make provision or *degrees* for those qualifying at the highest levels from the technical colleges. There are *two* degree-awarding machineries in the United Kingdom - the traditional universities and the new Council, responsible for awards of *degrees* to those pursuing highest level courses at technical institutions. (In addition to the traditional range of subjects, degrees are awarded for subjects such as ceramics, fermentation, and quality control.)

## **5. The Problem of Quality**

I have spoken so far of the structural problem of education. After this structure is set right we face the still harder problem - that of quality. The problem arises from two conflicting demands:

- (a) the student's desire to acquire a degree as inexpensively as possible - the degree acting as a hedge against unemployment.
- (b) the safeguarding of the quality of education.

As stated in the first part of this memorandum, one has to accept that a bachelor's degree in academic or professional disciplines - whether in arts, sciences, technology, commerce, accountancy or agriculture - is the "birthright" of every Pakistani student, just as it is in all democratic societies. A natural corollary of this is that the preparation for the first degree and its intermediate steps should be allowed to proceed in all types of institutions - polytechnics, training institutions, night classes, private colleges, coaching colleges (with, of course, an inspection system to prevent fraud). For one thing, the

termination of the present monopoly by approved colleges will inevitably bring down the expense of obtaining a degree.

To preserve quality, however, in such conditions one must also accept - as is the case in the United States - that *post-graduate* education will take longer than hitherto and will be decisive in preserving standards. One practical suggestion - a crucial structural one - that must be taken up is that special charters be awarded to selected self-governing institutions - self-governing academically as well as administratively. Such institutions should remain part of the existing universities; they award the degrees of the parent university - like Imperial College, London, which awards London University degrees *but frames its own curricula and conducts its own examinations*. Among such institutions could be Government College, Lahore, Forman Christian College, Lahore, and the Dacca College, for example. These institutions could then be the touchstones of quality both at the undergraduate and post-graduate levels. Our educational system has been characterized by academic rigidity; the need is for a revivifying diversity.

## 6. Teachers

The quality of education depends, in the last analysis, on one thing alone - the quality of the teacher, his involvement with the creation of his subject, with creative teaching and with his pupils.

In the past the tendency has been to belittle the Pakistani teacher, to decry his attainments, to deny him influence in running his institution, to accord him a low social standing. This must change. Since the teacher is the pivot of the system, he is the one who must always be right.

Not till our secondary schools and junior colleges get staffed - as in Japan - by the (unemployed) M.A.s, M.Sc.s and Ph.D.s, will the quality of education improve. For this to happen it is essential to raise salaries. I would give a Ph.D. in a high school more salary than the one working in a research council.

For the universities, the problem is different. The problem here is of dead wood created by two factors:

- (a) The number of sanctioned university posts has been so small that no fresh blood has entered the universities for a long time.
- (b) The creation of his subject was never considered part of the duties of a university teacher. Even on a more elementary level, university teachers were denied the opportunity of keeping in touch with developments in their subjects; attendance at international seminars has been treated as an unnecessary luxury - to be frowned upon or at best sanctioned as a privilege rather than as a right.

The result of these accumulated years of neglect - often by educational authorities, vice-chancellors, secretaries of education, and heads of departments - has been to breed a type of university teacher who considers it his one duty to reproduce - year after year - the notes he made when he was himself a student twenty or thirty years ago. There is a lot of dead wood - created by the system. This may need chopping - painlessly, and with full compensation; one method may be by shifting teachers to other duties.

But where, immediately, shall the live teachers come from? Pakistan has two excellent reservoirs of first-rate teachers. First, there is the large number of first-rate Pakistani scholars at present in foreign countries. They will come back - salaries are not the first essential - provided they are given the guarantee that they will be financed so that they can keep in touch with the international community in their subjects. Second is the (surplus) reservoir in sciences of excellent men in the Research Councils of Pakistan - particularly the Council of Scientific and Industrial Research and the Atomic Energy Commission.

To elaborate on this: whereas the universities have had extremely meagre funds at their disposal, the funds with which the Research Councils have operated have been very much more generous. The equipment is better, the staff is younger, more vigorous, better trained. The universities never claimed and never obtained their share of *foreign training programmes*. The Research Councils do not need all the manpower they possess - definitely NOT. For the

last five years I have tried in vain to persuade universities and the fundamental research wings of the Councils to integrate - tried to persuade the universities to take surplus Councils staff - even with their salaries still coming from the Councils. I failed consistently. The problem is not peculiar to Pakistan. It is a problem faced by research councils and universities the world over - in the U.K., the U.S.S.R., and the U.S.A. Each country has devised a different solution to it.

The problem is artificial; it is one of jurisdiction, of statutes made without taking the country's needs into account. As I said before, no teacher at university level can remain a good teacher if he is not engaged in creating his subject. Likewise, there is the other side of the coin: a research institute which has no responsibilities in training the young must eventually become sterile. The answer to this artificial division of councils and universities is to merge them into one system as far as possible. There is, for example, no reason why the Ayub Research Institute at Lyallpur should not be a part of the Agricultural University next door. Likewise, for the Pakistan Institute of Nuclear Research at Islamabad; likewise for some of the laboratories of the Council of Scientific and Industrial Research. (A suggestion accepted by President Ayub Khan before he relinquished office was to effect a complete integration of Islamabad University and the Pakistan Institute of Nuclear Science and Technology at Nilore.) I would like a commission to be set up immediately which would undertake such integration wherever possible throughout the country - finishing this very artificial problem once for all. Only under Martial Law can this problem be solved.

#### *Student-Teacher Contact*

The university system of education in advanced countries has two indissoluble parts which receive equal emphasis:

- (a) formal lectures
- (b) tutorials

In Pakistan, for some curious reason the second has never been considered part of the instructional procedure. There is an immediate need to put proper

emphasis on tutorials, where a few students are individually coached by those who lecture (or by more advanced, post-graduate students, specially paid for this purpose). I cannot emphasize this important reform too much.

To summarise, the problem of provision of high quality teachers for university institutions is of the highest priority. It can be solved by adopting the following measures:

- (a) Research - an active engagement in the creation of his subject - must form part of the recognized duty of a university teacher. For this facilities must be provided. In some science subjects, the laboratories of the research councils - integrated into the university system - can do this.
- (b) Provision must be made so that university teachers keep in touch and feel themselves to be part of the world community of scholars.
- (c) University staffs must be increased in strength (by taking, for example, new staff from the Research Council) - the system of having a fixed immutable number of sanctioned posts with a pyramidal structure, professor, reader, lecturer, must be abolished. (This needs fluid funds in the hands of a central organisation such as the University Grants Commission or a Central Fundamental Research Council which can accommodate a scholar when he comes along.).
- (d) Teachers must have a greater say in running the educational system and their institutions.

#### *Autonomy of Pakistan's Universities*

Pakistani universities (and the chartered institutes) must be run by teachers themselves like universities all over the world and not by:

- (a) Government Education Departments;
- (b) Chancellors with no interest in their welfare, except to treat them as law-and-order problems;

- (c) Retired High Court Judges and so-called public men.

The measures necessary to ensure autonomy are well known. These include:

- (a) Building up the University Grants Commission receiving funds from the Treasury and disbursing university finance. (The higher education sector finance will have to be raised by a factor of five before we shall get a viable system).
- (b) Guaranteeing the university finances for five years and planning university programmes on a quinquennial basis.
- (c) Permitting solicitation of public endowments.

This autonomy should then extend to university departments, and also, of course, to the institutes with charters mentioned above, with governing bodies of their own, and finally to the individual departments of constituent research institutes within the universities.

Not considered in this note are the important problems of the technological and scientific bias of curriculum content, and of teaching in Urdu and Bengali, the measure needed to create a spirit of scholarship in the country, or the nation-building and humanising aspects of education. I hope to submit a separate note on these.

## **7. Students Politics**

In all universities I have experience of, there is a sector of activities - cultural and political - run wholly by students. Students are adults, highly responsible persons and they must be treated as such. But there needs to be an absolutely clear demarcation between what the students run and what the authorities run and a mutual acceptance of this line of demarcation. My past experience at Lahore was that most disputes between the two arose from Union affairs.

There is a fund which the authorities levy - wrongly called the Union Fund - which they use for the remission of fees and the maintenance of sports grounds and so on. Student Debating Union officials have always believed that these funds belonged to them and that the colleges or universities were their collecting agents. This double fallacy needs to be exposed. The fund which the authorities levy should not be called the Union Fund if it is not meant for student Union affairs; and the students themselves must raise funds for their societies and Unions. This is the pattern I am used to in Oxford, Cambridge and London, where the authorities provide no more than a Union building. This is run, maintained, and kept by students for students with no staff participation, and with subscriptions voluntarily collected.

A second bone of contention in Lahore used to be the messes - the refectories. In Cambridge and London the student Unions ran their own wholly-controlled messes - charging what they wished - and the authorities ran their messes - also for use by students and staff. There was a healthy competition between the two types of messes and I see no reason why this should not be the pattern in our colleges and universities as well.

This part of the note on student activities has, of course, been overtaken by events. I thought, however, I might set down the practice abroad as I know it.

### **Summary of Recommendations**

Three commissions need to be created. One to create a credible and prestigious professional technical, commercial, vocational and agricultural education system. A second, to create an autonomous university system, comprising self-governing institutions of quality with charters of their own. A third, to consider the problem of staffing, the rights and privileges of teachers and the problem of the integration of the staffs and laboratory facilities of the Research Councils of Pakistan with the University Research System.

## TABLE OF ENROLMENT

Note the disastrous relative drop in (3) in the Technical-Vocational Sector in Pakistan as compared to the United Kingdom.

	Pakistan (1968)	England and Wales (1967)
(1) Primary *	8,000 (thousands)	4,500 (thousands)
Lower Secondary **	2,000 "	3,300 "
(2) Higher Secondary and Junior Arts and Science Colleges	300 "	700 "
Universities	27	168 "
(3) Technical-Vocational***	25	" 962 "
Professional Colleges (other than teacher training)	25	" 66 "
(4) Teachers training	30	" 96 "

The Pakistan figures are Third Five Year Plan projections reproduced from Table 5, p. 29 of Educational Development in Pakistan by Dr. W.M. Zaki (1968). The U.K. figures are from The Educational System of England and Wales (Department of Education and Sciences Publication 1968).

\* Pakistan's population is some two and a half times the population of England and Wales. Its enrolment at primary level is around 45% of the eligible population. (The proportion of children below 14 years of age in Pakistan is around 14% of the total population compared to 7.9% in Western Europe).

\*\* With the large drop-out in Pakistan at the primary level (mainly for economic reasons) it is clear that full-time trade and vocational training - particularly in agriculture - must already start after the primary stage.

\*\*\* These United Kingdom figures are for day scholars. In addition, there is an enrolment of 2,230 thousands - mainly adults - pursuing professional courses in the evenings.

# Technology and Pakistan's Attack on Poverty

*Address by Professor Abdus Salam at the XIII Annual All Pakistan Science Conference, Dacca, 11 January 1961.*

I wish to begin by offering my sincerest thanks to my colleagues for the honour they have done me in electing me as General President. I feel doubly proud because our meeting takes place in this historic city of Dacca. In my experience there is no part of Pakistan where scholarship in its own right carries more esteem, and where a scholar receives more personal affection than in East Pakistan. This unfortunately is a dying tradition elsewhere but one which lives in Dacca and I would like to begin by paying a tribute to this.

In my address today I would have liked to speak about the scientific field I have been privileged to work on, about the elementary particles of physics - those ultimate constituents of which all matter and all energy in the Universe is composed. I would have liked with you to explore the frontiers of our knowledge and of our ignorance, to tell you of some of the concepts the physicist has created to comprehend God's design. I would have liked to show you that, with all his pragmatism, the modern physicist possesses at once the attributes of a mystic and the sensitivity of an artist. I would have liked to convey to you some of the wonder, some of the fascination, as well as some of the heart-breaks of the physicist's craft.

But I shall not do this. In electing to speak on a general subject like Technology in relation to Pakistan's Attack on Poverty rather than on Elementary Particle Physics, I am following the illustrious tradition of my predecessors in this office. More particularly I have in mind the eloquent Presidential address on "Technology and World Advancement" delivered by Professor P.M.S. Blackett to the Dublin meeting of the British Association for the Advancement of Science in 1957. If I speak part of the time about the laws of economics rather than the laws of quantum physics, it is because like Blackett I interpret Technology not in its narrow industrial sense but as something embracing the scientific organisation of most modern life. There are times when, in all humility, a mere scientist may also express himself on

ideological matters, not because he has new insights to reveal but because there are things he believes passionately in, which need saying and cannot be said often enough.

We in Pakistan are very poor. This poverty we share with the majority of the human race, with some one thousand million people in about a hundred countries. Fifty per cent of us in Pakistan earn and live on less than eight annas a day; seventy-five per cent live on less than a rupee. This rupee a day includes the two daily meals, clothing, shelter and education if any. In contrast some four hundred million inhabitants of Europe and North America live on an average daily income of fifteen rupees.

It is important to realise that this uneven distribution of wealth is of a relatively recent origin. Three hundred and fifty years back Akbar's India and Shah Abbas's Iran compared favourably in living standards with Elizabeth's England. Soon after, however, the Western growth started. It coincided with a great technological advancement in agriculture and manufacturing methods. Now, technical advances on a limited scale have occurred from time to time in the history of human societies. These advances have always led to increased prosperity. What, however, distinguished the nineteenth century technological revolution was the fact that it was firmly based on a scientific mastery of natural law. This gave man so much power, and it has led to so great an increase in production that, for the first time in human history, there is no physical reason for the existence of hunger and want for any part of the human race.

The realization that hunger, ceaseless toil and early death can be eliminated for whole societies, and not merely for parts of societies, is something new. The last hundred years have seen nation after nation start with something like our conditions and crash through the poverty barrier. The laws governing this type of transformation are now well understood. First, a society must acquire the requisite technological skills; secondly, it must save and invest more than 5% of its national income in productive enterprises. This minimum of five per cent just about offsets the depreciation of existing wealth. To double the standard of living in forty years needs an investment rate of 10-15%; to double it in a decade, a nation needs to invest about 25% of its national income.

Skills and capital – these then are the two prerequisites for building up a self-reinforcing economic growth. Nation after nation has achieved this in the last two centuries, each nation leaving the imprint of its own peculiar experience. Four of these experiences – those of Britain, Japan, Russia and China – however, stand out clearly. The British were the first to show that the poverty barrier can be crashed through if skills and capital are available. The Japanese showed that technology is communicable; that it is easy to learn and acquire. Having been conditioned for years to look with misty, uncomprehending eyes at the engineering miracle of an airliner, I still remember having the shock of my life when I first visited the De Havilland Aircraft Factory at Hatfield. Instead of an organised assembly line where I expected to see molten aluminium being poured in at one end and a Comet airliner coming out at the other, all I saw was something like an overgrown metal-smith's workshop in rural Pakistan. And when two women in overalls lifted a couple of aluminium sheets while a third started welding them together with a manually operated welder to make part of the fuselage, I am afraid I lost my respect for the mysteries of the manufacturing craft.

I do not for one moment wish to suggest that all technology is electrical welding. There is the other part of the story - the aerodynamic design of the Comet where the high-level scientific talent come in. But the Japanese experience forced home the moral that technological competence is not a hereditary characteristic; that it can be acquired and in fact acquired rather quickly.

The third important lesson came from Russia. It showed that transition to sustained growth need not take a century or longer. It can be telescoped into the span of one man's life provided heavy industry receives top priority. And then finally there is the Chinese experience underlining that cheap labour is itself a form of capital.

Summarising the economic part of our argument: skills and sufficient capital rightly invested are the major ingredients of self-reinforcing growth. On the road to achieving sustained, compounded growth of this type all nations have left the imprints of their peculiar experience, but four stand out clearly: the British experience, showing that it can be done; the Japanese experience,

showing that technology is easy to acquire; the Russian experience, showing that a priority given to heavy industry accelerates the growth; and the Chinese experience, showing that cheap labour is itself a form of capital.

From this brief and sketchy economic summary, let us turn to the realities of the situation in Pakistan.

The facts of our poverty are obvious enough and I am not going to mince words about it. You can go out in the streets and see it all around you. I am not referring now to the obviously shelterless, the obviously needy. I have in mind more the uncomplaining millions, with their suppressed hunger, the millions who, and I speak from experience, seldom get the two regular meals of the day; the millions who must often choose between buying badly needed food or a school-book for their child. We live with a crushing poverty of the sort which Europe or America have not seen since the days when Dickens wrote. The marvel to my mind always is that the human spirit does not break and that most of the needy are still able to keep a dignified exterior.

The sense of what can be achieved, on the other hand, hits you most when you visit an affluent society like that of the United States. You just cannot believe the plenty - the plenty not for the few but for everyone. Everytime I am privileged to visit that great country, I have to remind myself afresh that it is indeed possible to produce so much for so many.

I do not say all this in any spirit of envy. This prosperity is due to an organisation of society where scientific knowledge is fully exploited to increase national productivity. This prosperity is a portent of hope; hope that possibly within our life-time, using the same methods, we in Pakistan may also achieve the same.

Our poverty raises not merely material but also spiritual issues. The Holy Prophet, may peace and blessings of Allah be upon Him, said "It is near that poverty may become synonymous with *Kufr*." I shall not attempt to translate *Kufr* into English; the nearest equivalents, apostasy or unbelief, can never convey the connotations which *Kufr* has for a Muslim audience. Let me say with all the vehemence at my command that I would

like to see this saying of the Prophet on the doorpiece of every religious seminary in Pakistan. There may be other criteria for *Kufr* as well, but in the conditions of the twentieth century, in my opinion the most relevant example of *Kufr* is the passive toleration of poverty without the national will to eradicate it.

I have mentioned technological skills and capital as the two pre-requisites needed before a pre-industrial society like ours can crash through the poverty barrier. Actually there is a third and even more important pre-requisite. And that is the national resolve to do so. In Professor Rostow's words, "a nation's take-off into sustained growth awaits not only the build-up of social overhead capital – capital invested in communication net-works, schools, technical institutes – it not only awaits a surge of technological development in agriculture and industry, but it also needs the emergence to political power of a group prepared to regard the modernisation of the economy as a serious high order political business". Such was the case in Germany with the revolution of 1848; such was the case in Japan with the Meiji restoration of 1868; such was the case with the Russian and Chinese revolutions. Our independence in 1947 could have provided us with the necessary stimulus. Unhappily this was not the case. Our independence did not - definitely did not - coincide with the emergence of a political class which made economic growth the centre piece of state policy. I can still recall the interminable arguments, conducted in private and public, in the early years of Pakistan, about its ideology. Never in these discussions did I hear the mention of total eradication of poverty as one of the primary ideological functions of our new state.

True enough the country registered commendable progress in the manufacture of consumer goods - though, one must not forget, with appalling suffering to the consumer himself. True enough the establishment of the Pakistan Industrial Development Corporation was a triumph. But at no time was this development purposefully designed to achieve the breakthrough we have talked about. The first five-year plan was commissioned in 1955, fully eight years after independence. It did not receive the formal approval of the Government till 1957. During these years there was a total neglect of the primary sector of our economy - agriculture; we squandered the windfall

surpluses of the Korean war boom in buying, on open general licences, European cosmetics and radiograms. It is not that we failed to develop basic heavy industries. But we did not even make any provisions for their future establishment; not even to the extent of starting to get our men trained in basic technologies. And, lastly, we completely neglected the exploitation of our minerals. Not even a survey was undertaken.

It would be right to date our progress towards a point of "take-off" from the assumption of power by the present Government. I believe that when the future history of Pakistan is written the greatest significance of the revolution of 1958 will come to be recognised as the resolve for the first time of Pakistan's Government to achieve a breakthrough within five years. This resolve is reflected first in the recognition of a need for bold planning for agricultural development, for the exploitation of minerals and, most important of all, for the development of heavy industry. Secondly, it is reflected in the recognition that a liberal provision for developing technological and scientific skills is the wisest investment a nation can make.

Take our new five-year plan first. It is a sagacious plan, though perhaps not as audacious as I would like to see. It aims at achieving the crucial 10-15% investment level. It places due emphasis on our primary sector of agriculture. It envisages the beginning of a basic heavy industrial complex, particularly the steel industry. And, most important, it sets about exploiting our one industrial source material - the Sui and Sylhet gas - to set up a petrochemical industry.

Quite often one hears abroad the rather sneering statement that underdeveloped countries look upon steel mills as national monuments. I personally confess to this preference for national monuments and for very good economic reasons. Without a heavy industrial base nothing is possible in the long run. To take one pertinent example given by Professor Mahalanobis - the great Indian statistician - let us consider the problems of providing 700,000 tons of extra grain needed for the five million annual increase in the Indian population. There are four ways of getting this extra grain: buy the grain; buy fertiliser to grow the grain; buy the plant to make the fertiliser or, finally, build the heavy engineering capacity capable of making fertiliser

plants. The cost of buying grain works out at 300 million pounds; the cost of buying fertiliser is one-third of this; and the cost of the fertiliser plant about one-fourth. But the real saving comes if one sets up the heavy manufacturing capacity to make fertiliser plants. The cost then is just some 10 million pounds. If the last alternative is chosen, however, one must start planning some eight or 10 years in advance of the season in which the fertiliser would be used.

It is gratifying that so far as fertilisers are concerned, our planners have chosen the third alternative. We are not planning to buy fertiliser but we shall make it in the country. Personally, of course, I would strongly favour Mahalanobis's last alternative – to set up the heavy manufacturing capacity within the country to make fertiliser factories. The Second Five Year Plan has made a beginning towards this by contemplating steel production of 400,000 tons. As steel producers and consumers it will put us in the same world class as the Republic of Chile and although I cannot say I feel satisfied with this, it is at least a beginning.

Turning again to the question of the 10-15% capital investment needed for achieving the economic breakthrough, there is a vital 3% which must be provided for in foreign exchange to buy foreign goods, foreign machinery and foreign know-how. It is this crucial 3-4% which must come from the advanced countries either in the form of long-term loans or outright gifts. During 1957-58 over the world, some two and a half billion dollars were provided by U.S.A., U.K., U.S.S.R. and France as aid to underdeveloped countries. Let us make no bones about it: this gift entails sacrifices for ordinary people like ourselves in the donor countries. In the United States, stores always show prices without the federal tax. The tax is added on at the counter so that one is highly conscious of the extra imposition by the time the purchase is completed. Thus whenever shopping around I have had to pay the ten cents federal tax, the thought that at least a quarter of a cent was going into foreign aid lightened the burden for me. It also gave me added respect and admiration for all those who constantly make this sacrifice.

The economists have estimated that for this aid to have a full impact, it must be stepped up from two to at least three billion dollars annually and be kept

at this level - with a guaranteed continuity - for a very long time to come. To get the scale right, it is perhaps worth mentioning that the Marshall aid to Europe just after the War ran to about twice this figure, though of course the rapid recovery of Europe made its continuance unnecessary after three years.

As I said before, the aid is a gift and it necessarily entails sacrifices and there is very little we can offer in return - at least for a very long time. Whether it will or will not be forthcoming is in the end a moral and spiritual question. I can only quote sages like Rostow who has spoken of "the resources of spirit, will, and insight which the West needs, quite as much as steel and electric gadgets, to do the jobs which extend not only to missile arsenals and the further diffusion of welfare at home" but to the Five Year Plans of nations abroad. I can only quote Blackett when he speaks about "the uneven division of wealth and comfort among the nations of mankind, which is the source of discord in the modern world, its major challenge, and unrelieved its moral doom". I do not know if a future historian will find it ironic that in the 1960s three billion dollars of aid were not easy to find while 60 billion dollars were annually spent stocking the world arsenals with atomic weapons, missiles and rockets. And I find it strange that during 1957 - 58, while underdeveloped countries received 2.4 billion dollars in aid, they lost 2 billion dollars in import capacity - in getting paid less for the commodities like jute and cotton which they sell and in paying more for the industrial goods which they buy. Paul Hoffman calls this a "subsidy or contribution by the underdeveloped to the industrialised countries" - a subsidy which almost entirely negated the entire sums received in aid. And as a physicist, I find it the height of hypocrisy to pretend that the man-made satellites orbiting in space and each costing at least as much as the entire annual budget of Pakistan have been sent up only to collect data on cosmic rays. All this makes no sense. It all points to one thing: the bankruptcy of world statesmanship in dealing with problems of hunger and want. Dare I say that what the world needs today is a great successor to Keynes to preach on a global scale that the raising of living standards of any depressed region is a collective world responsibility? Dare I say that we need a great successor to Roosevelt to give a New Deal not simply to one part of the United States but to a large part of the human family?

I have talked so far about our plans and the position regarding capital. I now wish to turn the question of the provision of technical skills. And this is where we as scientists come in.

Nowhere more than in this respect can we see the force of my remarks regarding the recent change of climate in Pakistan. This change is embodied particularly in the work of the Education and the Scientific Commissions.

Consider first the category of technicians who understand the scientific foundations of their craft. It is an awful fact but nevertheless true that in the entire educational history of British India, dominated by the liberal arts, there was never anything analogous to the British National or Higher National Certificates in Technology. I could not believe it when I was first told that Great Britain has 300 colleges of Technology spread all over the country training 30,000 technicians every year. One of the most far-reaching recommendations of the Education Commission is the provision to establish enough technical schools and polytechnics to produce 7,000 technicians a year. Our major problem is the staffing of these technical institutions. I purred with pride last year when Sir John Cockcroft spoke to me about the excellence of our army technical schools and their technical instructors. I am sure it will not be impossible to tap this reservoir for providing teachers in the early stages.

We in Pakistan are disposed to think of Scotland as a prosperous state within the British Commonwealth. I was startled the other day to read an article by Dr. J.M.A. Lenihan entitled "What is wrong with Scotland?" After painting a rather gloomy picture of consistent economic decline, Dr. Lenihan concludes that this decline stems entirely from lack of trained technologists. To the objection that if there is no industry in Scotland, there is no need for technical colleges, Dr. Lenihan counters by remarking that "the scientist, the technologist and the technician are, in the main products of the educational system, not of the industrial system in which they hope to work. A coherent demand for technical education facilities will not arise from an assortment of industries but the existence of technically trained people will facilitate the growth of new industries".

Dr. Lenihan's viewpoint about skills coming before industrialisation has, of course, a peculiar relevance to our situation in Pakistan. Some ten days back I heard a similar comment from Professor S. Tomonaga, the great Japanese physicist, now President of Tokyo University. Speaking of the spectacular rise of the Japanese transistor industry, Professor Tomonaga attributed it to a careful cultivation of the art of calligraphy. Every Japanese child must spend years learning the calligraphic arts at school; this develops a sensitivity of touch, a nimbleness of fingers, peculiarly suited, as they have now discovered, to transistor assembly and development. Clearly no skills or special talents a nation may cultivate are ever wasted when the spark of industrialisation comes along.

There is one other passage from Lenihan's address which I would like to quote. After listing a number of difficulties which face the Scottish economy, he goes on to say that "many of the difficulties that have been mentioned are the natural consequences of living in a country" - that is Scotland - "where science is not taken seriously enough. How else can we describe a country which, fighting for economic survival in a world dominated by technology, allows the basic sciences of physics and chemistry only the status of half subjects in the school curriculum." There is perhaps in Dr. Lenihan's remarks a considerable moral for Pakistan's secondary education.

Perhaps the most depressed community, till recently, among technicians in Pakistan was - and so far as University teachers are concerned still is - the community of scientific workers. All scientific research institutes in Pakistan have been run under the uncomprehending bureaucratic control of Government Ministries. And when I say control, I mean control. We seem never to have recognised that in a science-dominated world there ever could be any tasks for Pakistani scientists. The official attitude towards science has at best been one of reluctant indulgence; somewhat like the attitude of the learned divines in the worst and most intolerant days of the Bukhara Emirate towards the local clockmaker who was a Christian. He was permitted to enter the mosque to repair the tower clock only on the plea that, after all, in the matter of technical usefulness he was on par with the donkeys which carried the stone slabs into the mosque in the first place. Why should the clockmaker suffer such a social slight? Not only did our bureaucracy adopt

the divines' attitude to the clock-maker but also, if possible, they hired the clockmaker from abroad.

One aspect of this neglect is the awful fact that there are so few of us in the country. According to the statistics collected by the Scientific Commission there is a total of sixty trained physicists in Pakistan. To get the scale right, this is roughly the number of correspondingly trained men you may find in any one London college. In scientific research, unfortunately, it is no longer possible for a single person to achieve his individual breakthrough. Before science can flourish and a scientific tradition can develop, there has to be a critical size, a critical number of trained scientists at one place. Once the critical number is reached, the chain reaction starts; the group become self-reacting. Otherwise it simply withers and dies away.

I have great hopes that all this is going to change. As you know, a Scientific Commission was appointed by the Government last year, and it has presented its report. From the manner the Government has reacted to the reports of its previous Commissions, I venture to predict that 1961 may be the beginning of a new era for scientific research for its organisation, for the massive training programmes which may be initiated and for the calls which the nation may make on its scientific talent. I only hope we, as scientists, can rise to the challenge and are not found wanting and unprepared.

What exactly are the tasks where we as scientists can make an immediate contribution? One could list a number, ranging from problems of low productivity in agriculture, problems of flood control and water logging, to the optimum use of Sui gas. To take one concrete example, a new method for gas-reduction of low grade iron ore has been developed in Mexico. Most steel producing countries are, of course, not interested in gas-reduction for they possess plentiful supplies of coke. The Mexican process is producing one million tons of steel annually. Our situation in Pakistan is similar to that of Mexico. We possess gas as well as low grade iron ore. It is gratifying that our Department of Scientific and Industrial Research has independently started a small development project for the process. If successful, it may revolutionise our steel economy. Would you not agree that the project needs top most blessing and the highest priority?

I would like to end by briefly reiterating some of my remarks. In hoping to achieve the breakthrough to national prosperity, we depend, like most other poor countries, on numerous factors beyond our national control. But there are a number of internal prerequisites the nation must satisfy before the transformation of our society can take place. The first and foremost of these is the firing-up of the entire nation and harnessing of its spiritual energy to the objective of the eradication of poverty within one generation. This will need constant reiteration of the economic objectives; in particular, convincing the nation that the economic policies are designed to enrich the whole society and not merely a part of it. I do not know how the youth of Dacca spend their evenings but as a measure of the nation's consciousness, I shall feel happy when Lahore, for example, makes a transition from its present literary to a technological culture and instead of love-lyrics in the Mall cafés the discussions range freely and fiercely - at least part of the time - over the targets of the Five Year Plan.

Let us be absolutely clear about the nature of the revolution we are trying to usher in. It is a technological and scientific revolution and thus it is imperative that topmost priority is given to the massive development of the nation's scientific and technological skills. And finally let us as scientists face and live up to the challenge thrown up by Pakistan's poverty. Let future historians record that the fifth important lesson in the economic transition to prosperity was taught by Pakistan in achieving a rate of growth as rapid as the Russians and the Chinese but without the corresponding cost in human suffering.

Let me end by quoting from the Holy Quran.

إِنَّ اللَّهَ لَا يُغَيِّرُ مَا بِقَوْمٍ حَتَّى يُغَيِّرُوا مَا بِأَنْفُسِهِمْ

The Lord changeth not what is with a people  
until the people change what is in themselves.

# Nuclear Physics in Pakistan

*International Seminar on Low-Energy Nuclear Physics held at Dacca, 16 - 25 January 1967: Presidential address on the opening day.*

Almost exactly twelve hundred years ago, Abdullah Al Mansur, the second Abbaside Caliph, celebrated the founding of his new capital, Baghdad, by inaugurating an International Scientific Conference. To this conference were invited Greek, Nestorian, Byzantine, Jewish as well as Hindu scholars. From this conference - the first International Conference in an Arab country - dates the systematic renaissance of science associated with Islam. The theme of the Conference was Observational Astronomy. Al Mansur was interested in more accurate astronomical tables than were available then. He wanted, and he ordered at the Conference, a better determination of the circumference of the earth. No one realised it then, but there was read at the Conference a paper destined to change the whole course of mathematical thinking. This was a paper read by the Hindu astronomer Kankah on Hindu numerals, then unknown to anyone outside of India.

My colleagues from the United States, from USSR and from Europe will forgive me if I sound parochial in recalling today this long past occasion in the history of science. I recall it for, to us in Pakistan, who trace our cultural heritage from Baghdad, what happened at that Conference is of direct relevance even today and its remembrance still a peculiar source of inspiration. Then, as now, we in the East, could not boast of a strong continuous tradition of scientific research. Baghdad then, like Dacca today, was not one of the great intellectual centres of the world. And astronomy then, like nuclear physics today, represented one of the sophisticated disciplines on the frontiers of human knowledge, remote from the realities of life in Iraq. It seemed to some presumptuous to hold such a concourse of scholars in a relatively little known metropolis of Baghdad on a subject of little practical interest. But to compensate for this, there was then, as there is now, among the nation the first flush of a youthful nationhood; an up-lifting exaltation shared by men of vision, all necessary for high endeavour.

Al-Mansur's Conference succeeded beyond all expectations. It laid the foundations of astronomical and mathematical studies in Islam; out of this conference grew the idea of the founding of one of the world's first International Academies for Scientific Research, the Bayt-ul-Hikma. But even on the more practical, more pragmatic plane, from this conference dated the architectural and engineering studies of Naubakht and Mashallah, both of whom attended its sessions and who were later responsible for some of the major monuments of Baghdad. From this conference dates the craft of instrumentmaking in Baghdad the specimens of which still survive in the masterworks of Isa Asturlabi.

No one can say whether the contributions at our meeting today will in retrospect of history make this symposium appear as significant for nuclear science itself as that meeting at Baghdad. But in all humility let me say this: this first International Symposium on Nuclear Science will inevitably quicken the pulse of the subject in Pakistan. The fact that we are so fortunate as to welcome so many distinguished and leading world physicists today betokens that work done at the centre at Dacca is of world quality; it is a portent of the hope that the community in Dacca, and in Pakistan, normally so isolated, will become integrated as part of the mainstream of the international scientific community, that Dacca from now on will count as one of the international centres of significance receiving and, I hope, giving as well. The holding of this seminar and others like it is part of the conscious policy of President Mohammed Ayub Khan and his government to encourage science to the utmost. Without this interest neither this centre nor this conference - nor indeed the AEC of Pakistan - would have come into existence or worked at the pitch that it has.

Not all of us here today are nuclear physicists. We are grateful to those who are not, and still could spare some of their time to come here and join us. It is perhaps appropriate that to those who are not professional nuclear physicists I may say a few words about the scientific significance of the Symposium, and relate it, in perspective, to the work of the Atomic Energy Centre at Dacca.

The science of Nuclear Physics began early in this century with Rutherford and Chadwick in the Cavendish Laboratory. Their work was part of the chain of

man's age-old quest for discovering the ultimate, the fundamental constituents of matter. Rutherford and Chadwick showed that all the then known 92 atoms of hydrogen, helium, lithium ... up to uranium, consisted of a central nucleus, surrounded by a cloud of electrons. These electrons outside the nucleus concern the chemist, the biologist, but they do not concern the nuclear physicist. For him they are irrelevant. What matters to him is that all nuclei of whatever atom consist of just two fundamental particles, protons and neutrons. The nucleus of helium for example consists of two protons and two neutrons, of lithium of three protons and three neutrons; of beryllium of four protons and four neutrons and so on. The nuclei are bound systems, held together very tightly by strong attractive nuclear forces. The central problem of nuclear physics is the precise determination of this nuclear structure; how the protons and neutrons are arranged in a particular nucleus; how they move inside it; what precisely is the nature of the nuclear force. Strange as it may seem, Hiroshima notwithstanding, we still have not solved the problem of the nuclear force. Strange as it may seem, we still foster rival schools of nuclear structure, as disputatious among each other as any theological seminary.

I said the nuclear forces are very strong forces; the nucleus is a very compact entity. Just how compact - we can get an idea of this if we compare the nuclear forces with the weak electrical forces which bind the outer electrons in atoms to the central nuclei. Clearly the stronger the force, the tighter the binding it will produce. A typical nucleus is some hundred thousand times smaller than a typical atom. If an atom could be blown up to the size of the city of Dacca, the size of its nucleus would not exceed the size of one of the tables in this lecture hall. I am emphasizing this greater strength of the nuclear force, this tighter binding of nuclei compared with the atoms, because therein lies the excitement, the fascination and, of course, the heartbreaks of a practising nuclear physicist.

Why is it relatively more difficult to get information about the structure of nuclei and the nuclear force compared for example to atoms? The reason is simple. Our only means of probing into the structure of atoms or nuclei is to try to penetrate these structures by fast-moving electrons or protons. In its passage through a nucleus, a fast-moving proton either gets deflected, or it may eject on impact a piece of the target nucleus. By studying the projectile after it

has emerged from the target, by comparing its velocity before and after, by measuring the deflection it may have suffered, by analysing the bits of the target nucleus it may eject, we build up, piece-wise a picture of the inner structure of the target. It is an indirect, a painstaking, a slow process. It is like a jet of water playing on the face of a beautiful statue. Suppose the statue is in the dark; analysing nuclear structure is similar to reconstructing what the statue looks like, from just the splashes of the jets of water playing on the face of the statue.

Now the relative smallness of nuclei and their tighter binding makes it imperative that the projectiles one may use to hit a nucleus should be very fast-moving. A cannon-ball fired from the outskirts of Dacca would have to be really fast-moving to hit a table in this room. In the Dacca Van de Graaff accelerator, protons are accelerated to three million electron volts before they are made to hit a target nucleus of iron, aluminium, or copper presented to them. At this energy the protons are moving at a speed of 18,000 miles a second, nearly one tenth of the velocity of light.

The Dacca accelerator was commissioned in early 1965. It is one of the two reasonably energetic accelerators in the sub-continent. The experimental research group at Dacca has used it to study a number of nuclear reactions. Among the studies presented by the group at the conference are the results of deuteron bombardment of  $^{56}\text{Fe}$ . The bombardment converts  $^{56}\text{Fe}$  to a new isotope of iron,  $^{57}\text{Fe}$ . The group has studied the excited states of this isotope which is produced as a result of the impact. This is the first detailed systematic and accurate work on the energy levels of  $^{57}\text{Fe}$ . By studying the angular distribution of outgoing protons, as many as 26 energy levels were discovered. The work was so accurate that it was possible to determine the angular momentum values of 14 of the newer levels. Another experiment concerned scattering from Vanadium 51. One of the more ambitious projects is the studying of proton gamma reactions using a spectrometer and a scattering table designed and constructed with the help of Professor P.M. Endt from Utrecht whom we are very glad to see here with us today. We all sincerely hope one of the direct fruits of the conference will be a better and still better gearing of this Van de Graaff accelerator for the exploration of nuclear structure.

I said earlier that the higher the energy of a projectile the deeper we can probe into the structure of matter. I said the Dacca accelerator can probe down to  $10^{12}$  -  $10^{13}$  cm. This is the domain of what we call Low Energy Nuclear Physics. With projectile energies of the order of a few tens of million electronvolts. Beyond these energies lies the domain of High Energy Physics. The most powerful accelerators in existence today can accelerate protons to energies of the order of 30 GeV, some 10,000 times higher than the proton energies available at Dacca. These powerful accelerators, situated at Brookhaven in the United States and at Geneva in Switzerland, consist of a magnet in the form of a ring, a hundred meters or more in radius. These accelerators and a similar one at Dubna in the USSR have been utilised to probe into the structures, not of nuclei, but of their constituents the protons and neutrons themselves. One has discovered that the protons and neutrons are possibly not as elementary as one had assumed them to be; they are possibly parts of still larger families of particles. One is even led to the suspicion that they are themselves made up of perhaps still more elementary units. As it happens even the 30 GeV accelerators are not powerful enough to confirm or demolish these suspicions. The next phase in the unravelling of the mystery of the structure of matter must wait accelerators of still higher energy. A few days ago Professor Seaborg told us that the U.S. Atomic Energy Commission expects around 1974 to commission a 200 GeV accelerator near Chicago, another order of magnitude more energetic than the accelerators now in existence. The magnet ring of this projected accelerator will be of the order of 1 mile in diameter.

I am mentioning these machines and the possibilities of exploring still deeper into the structure of protons and neutrons for a very special reason. Even though these facilities are extremely costly – for example the European Council for Nuclear Research which runs the Geneva Laboratory collaboratively on behalf of some 14 European countries spends of the order of 15 million dollars annually – they, as well as U.S. Atomic Energy Commission and the Joint Research Institute at Dubna have been extremely generous in making available their facilities as well as their data internationally to all those working in this field. We in Pakistan have taken advantage of this. There is a very strong group of theoretical physicists working both here in Dacca as well as at Atomic Energy Centre, Lahore, which depends on data

published by these laboratories to try to elucidate the structure of the proton and the neutron themselves. These groups have published some 16 papers in the last few years. Some of these papers are of considerable significance in the subject. We feel proud that Pakistan has already achieved international recognition with this very low-cost theoretical work.

Coming back to the Seminar itself, as I said earlier, we are most fortunate in having among our speakers some of the world leaders in nuclear physics. The conference is divided into four major sessions, two on nuclear theory and two on experimental techniques. In the theoretical sessions we are hoping to listen to lectures from Professor Mottelson, Professor Malik, Professor Endt and Professor French dealing with problems of nuclear structure while Professor Moringa and Dr. Huby from Liverpool would speak on aspects of nuclear reaction theories. In the experimental sessions, Professor Starfelt, Dr. Allen, Dr. Alburger and Dr. Dearnaley are scheduled to give us an idea of the newer nuclear instrumentation and the recent techniques developed for the detection of particles. As a theorist (and as one who tried his hand but did not possess the patience, the skill and the strength of character which distinguish an experimenter) I harbour the greatest feelings of admiration and respect for the craft of experimental nuclear physics. The experimental physicists are the ones who by their invention of newer techniques open windows on nature through which one can glimpse reality.

The seminar, as indeed the AEC at Dacca, were conceived by Dr. I.H. Usmani. It is to his vision, his wisdom and his vigour that we owe this most remarkable development in nuclear science in Pakistan. The seminar itself owes its organization to the dynamic leadership provided by Dr. Anwar Hossain. All participants would wish to thank him and his devoted bank of colleagues for their tireless work in bringing the seminar into being.

I have deliberately concentrated my remarks on the fundamental and basic aspects of nuclear science. Indeed these are the aspects this symposium will emphasize. This however should not give the impression that what we are going to discuss and review has no relevance to life. It is an important facet of the exploitation of nuclear energy that we should understand as deeply as possible the way nuclei behave. But even if there was no such direct

relationship I would not apologize – just as the men of Baghdad were unapologetic - for pursuing fundamental science. It is absolutely imperative in the life of a young and a vigorous nation that it should devote some of its resources towards joining the great adventure of science. To conclude, there are in science few adventures, few challenges more exciting than the challenge of the structure of matter. Indeed, part of the fascination of our subject lies in the fact that in nuclear research we have recreated in our laboratories on earth a world of phenomena the natural place of which is outside of our abode here; the natural abode of which lies in the centre of stars. Of this fascination of basic research perhaps none has spoken with greater eloquence than George Wald of Harvard:

"Surely this is a great part of our dignity as men, that we can know, and that through us matter can know itself; that beginning with protons and electrons, out of the womb of time and the vastness of space, we can begin to understand: that organized as in us, the hydrogen, the carbon, the nitrogen, the oxygen, those 16 to 20 elements, that water, the sunlight-all, having become us, can begin to understand what they are, and how they came to be."

We in Pakistan are fortunate that we are also able to contribute to this understanding.

# Ideals and Realities

*Lecture given by Abdus Salam at the University of Stockholm, 23 September 1975. Published in a shorter version in Bulletin of the Atomic Scientists, September 1976.*

I am deeply honoured and much appreciate the opportunity to give the first lecture in this series on Human, Global and Universal Problems, particularly just after the conclusion of one of the most momentous of special sessions of the United Nations General Assembly dealing with this subject. This session, as you all know, was convened to discuss the global crisis in the human family's continuing and near-permanent polarisation between the rich and the desperately poor and the latter's demand for a *New International Economic Order*. I have looked forward to the opportunity of speaking to you today because I know that Sweden is one of the few countries of the world which has understood the issues; it is the ONLY country at present which is fulfilling the United Nations targets of aid. Its youths led the world in 1972 so far as global concerns go. My purpose today is to have a dialogue with you and to explore what are the ways in which the almost total incomprehension among the rich nations of what the poor are really demanding can be removed – and the urgency of the crisis mankind is facing brought home to developed societies.

The short-term crisis the world faces is simply this: the developing world – some nine-tenths of humanity – is bankrupt. We – the poor – owe the rich – one-tenth of mankind – some 50 billion dollars. The poorest amongst us cannot even pay the interest on our borrowings – far less find the 10 billion dollars we collectively need to import 10 million tons of cereals every year to feed ourselves. My own country, Pakistan, owes some 6 billion dollars – roughly equal to Pakistan's GNP for one year, roughly equal to Pakistan's six years' export earnings. Last week's London's prestigious *Economist* magazine starkly said, "The poorest among the poor who can neither borrow more nor draw on reserves will cut on their imports – their people will simply starve".

But this short-term crisis is only a part of a longer-term crisis. Our world is terribly unbalanced in income and in consumption. At least three-quarters of the world's income, three-quarters of its investment, its services and almost all

of the world's research are concentrated in the hands of a quarter of its people. They consume 78% of its major minerals, and for armaments alone, as much as the rest of the world combine. In 1970, the world's richest one billion earned an income of US\$ 3,000 per person per year; the world's poorest one billion, no more than a US\$ 100 each. And the awful part of it is that there is absolutely nothing in sight – no mechanism whatsoever – which can stop this disparity. Development on the traditional pattern – the market economics – is expected to increase the one hundred dollars per capita of the poor to all of one hundred and three dollars by 1980, while the US\$ 3,000 earned by the rich will grow to US\$ 4,000 – that is an increase of US\$ 3 against US\$ 1,000 over an entire decade.

No wonder the poor nations consider visions of any growth and development on the traditional economic system a vicious fraud. This is the system which in the last 20 years created liquidity and credits of 120 billion dollars allocating just 5% of these to the poor nations. This is the system, which pays 200 billion dollars for world commodities, but only one-sixth of this reaches the primary producer himself – the rest, five-sixths, going to the distributor and the middleman in rich countries – this is the system which gave 7 billion dollars of aid last year and took away almost exactly the same amount from the poor in depressed commodity prices. No wonder they are demanding in Omar Khayyam's words, "Ah love! could tho and I with fate conspire, to grasp this sorry scheme of things entire, would not we shatter it to bits – and then remould it nearer to the heart's desire".

Over the past three to four years, some of the brighter young economists of the Third World countries, Brazil, Mexico, Algeria, Pakistan and others – helped by some of the most distinguished figures in World Economics – have been groping towards a new synthesis of development and outer limits of growth. I am ashamed for my own profession, for there were no scientists or technologists associated with them. It is this new synthesis – embodied in the so called Cocoyoc and Rio declarations – which formed the basis of the Resolution on a Declaration on Establishment of a New International Economic Order, adopted in 1974 by the sixth special session of the United Nations Assembly. The present session – just concluded, was the follow-up from the last – it was convened to put some teeth into the Charter of

Economic Rights promulgated by the United Nations Assembly in 1974.

Among the poor – these Declarations have been likened to the great Declarations of Rights of M<sup>B</sup>an in the 18th century by Tom Paine – and the Communist Manifesto of the 19th century. What the establishments in the richer countries really think of the International Economic Order is hard to fathom. During 1974, the reaction might have been typified by the words of one of the richer nations' delegates to the United Nations who referred to the "shadow world of rhetoric" and "The drawback of so many short-lived resolutions, each longer than the last, one a repetition of the other, virtually unreadable ..." This year, though the response was still not outright commitment, Dr. Kissinger presented to the Assembly, on behalf of the richer nations, a welcome package of co-operative funds, joint institutes and aid initiative. I shall speak of these later, but in any case what is needed is not just that the Foreign and Finance Ministries of the developed countries should respond to the demands of the poor, but that the intellectuals and the general public become aware of these and truly comprehend them.

In this spirit, I shall therefore try to convey to you how a humble natural scientist from a developing country – who is not an economist, but one who passionately loves the United Nations and its work – views the global crisis of the disparity of the rich and the poor.

To get behind the psychological thinking of the poorer humanity, you must understand how recent in our view this disparity – which makes untermenschen of us today – is. It is good to recall that three centuries ago, around the year 1660, two of the greatest monuments of modern history were erected, one in the West and one in the East; St. Paul's Cathedral in London and the Taj Mahal in Agra. Between them, the two symbolize, perhaps better than words can describe, the comparative level of architectural technology, the comparative level of craftsmanship and the comparative level of affluence and sophistication the two cultures had attained at that epoch of history.

But about the same time there was also created – and this time only in the West – a third monument, a monument still greater in its eventual import for humanity. This was Newton's Principia, published in 1687. Newton's work

had no counterpart in the India of the Mughuls. I would like to describe the fate of the technology which built the Taj Mahal when it came into contact with the culture and technology symbolized by the Principia of Newton.

The first impact came in 1757. Some one hundred years after the building of the Taj Mahal, the superior firepower of Clive's small arms had inflicted a humiliating defeat on the descendants of Shah Jahan. A hundred years later still – in 1857 – the last of the Mughuls had been forced to relinquish the Crown of Delhi to Queen Victoria. With him there passed away not only an empire, but also a whole tradition in art, technology, culture and learning. By 1857, English had supplanted Persian as the language of Indian state and learning. Shakespeare and Milton had replaced the love lyrics of Hafiz and Omar Khayyam in school curricula, the medical canons of Avicenna had been forgotten and the art of muslim making in Dacca had been destroyed making way for the cotton prints of Lancashire.

The next hundred years of India's history were a chronicle of a more subtly benevolent exploitation. I shall not speak of this, but only of the scientific and technological milieu I was brought up in as a young man in British India. The British set up something like 31 liberal High Schools and Arts Colleges in what is now Pakistan, but for a population then approaching 40 million people, just one College of Engineering and one College of Agriculture. The results of these policies could have been foreseen. The chemical revolution of fertilisers and pesticides in agriculture touched us not. The manufacturing crafts went into complete oblivion. Even a steel plough had to be imported from England. It was in this milieu that I started research and teaching in modern physics some 25 years ago at Lahore, in the University of the Panjab.

Pakistan had then just won its independence after one hundred years of British rule. We then had a per capita income of US\$ 80 a year, a literacy rate of 20%, a population growing 3% a year and an irrigation system for agriculture which was breaking down. There was no social security and there was high child mortality – only five children out of twelve lived beyond one year. A child – a male child – was the only social security for old age one could budget for, making high birth rate imperative.

Pakistan – very willingly – accepted to become part of the free world economic bloc. We were relieved of worries of increasing population needing growing of more food. The US surpluses of wheat – under P.L. 480 – gratefully came, at first, in such abundance that one of our Finance Ministers spoke of curtailing wheat cropping in Pakistan by law to grow tobacco instead. We imported highly talented Development Planners from Harvard University. They told us we did not need to put up a steel industry. We could in any case buy any amount from Pittsburgh. We leased out our oil imports and even the distribution of petroleum products within the country to multinationals who conducted – in that age of oil surpluses – a half-hearted search for it.

Pakistan was thus a classic case of a post-colonial economy; political tutelage was interchanged for an economic tutelage. In the scheme of things, we were to provide cheap commodities – principally jute, tea, cotton, raw unprocessed leather. It was in 1956 that I remember hearing for the first time of the scandal of commodity prices – of a continuous downward trend in the prices of what we produced, with violent fluctuations superposed, while industrial prices of goods we imported went equally inexorably up as a consequence of the welfare and security policies the developed countries had instituted within their own societies. All this was called Market Economics. And when we did build up manufacturing industries with expensively imported machinery – for example, cotton cloth – stiff tariff barriers were raised against these imports from us. With our cheaper labour, we were accused of unfair practices.

To give you an idea of these tariffs – suppose Pakistan exported cotton seeds, these would attract only US\$ 100 a ton as tariff. But woe-betide if the seed was crushed into oil. The oil fell into the category of manufactures, and the tariff shot up to US\$ 600. We were to be markets for steel, for machinery, for fertilizer, for armaments. We must not export anything remotely resembling manufacture. No wonder we have been bankrupted.

Of indigenous science and technology – or indeed of any technological manpower development – there was neither need, nor appreciation, nor any role for it. Any technology we needed, we bought. It came hedged with all types of restrictions. For example, no product which used this technology could be exported. And in any case, not all technology was for sale. Pakistan, for

example, could not buy the technology of penicillin manufacture in 1955. My brother, together with a few other young chemists from Pakistan, re-invented the process, producing as a result of their inexperience penicillin at 16 times the world price. In the early 1950's, I looked upon my future as contributing to Pakistan's advance to technology and development as non-existent. I could help my country in only one way – as a good teacher – and that was to produce more physicists, who for lack of any industry, would in their turn, become teachers themselves, or leave the country.

But soon it became clear to me that even this role – that of a good teacher – would increasingly become impossible for me to maintain. In that extreme isolation in Lahore, where no physics literature ever penetrated, with no international contacts whatsoever and with no other physicists around in the whole country, I was a total misfit. I knew that all alone, I had no hope of changing Pakistan policies, so far as valuing science and technology were concerned. There was but one recourse, to make a call on the international scientific community to help in preserving one's professional integrity. My hope lay with the United Nations organisation and its agencies. And thus in 1954 started my involvement with these.

It is now two decades since I have been engaged in a very humble way with science and international affairs. I can divide this period into two distinct decades – the first decade from 1954 to 1964 – the decade of innocence and hope – and the second decade 1964 to 1974, of growing frustration and a feeling of hopelessness of it all. The third decade is beginning for me now. Perhaps this decade will bring more hope.

But to go back to my personal story; the first opportunity I got of playing a minor role in public affairs came in 1955 with the Atoms for Peace Conference held in Geneva. You may recall that this was the first scientific conference held under the United Nations auspices, the first conference when East-West secrecy, which extended till then to even trivial scientific information like neutron scattering cross-sections, was partly lifted. At this conference was promised atomic plenty to the world for energy, for isotope applications, for new and revolutionary genetic varieties of crops.

For me personally, this conference was important, for this was my first introduction to the United Nations. I remember entering that Holy Edifice in New York in June 1955 and falling in love with all that the organization represented – the Family of Man, in all its hues, its diversity, brought together for Peace and Betterment. I did not then realise how weak an organisation it was, how fragile and how frustrating in its inaction, but I shall speak of this later. It seemed to me then that any ideas I may have of helping Pakistan physics – and developing countries' physics – must be implemented through United Nations action.

The second occasion when I came in contact with the organisation came in 1958, at the Second Atoms for Peace Conference. This conference was similar to the one in 1955; its major achievement was a furthering of the process of declassification of nuclear fusion. For me, the greatest gain was that I had the privilege of working as a secretary under one of the greatest Swedes in international affairs – Dr. Sigvard Eklund – now Director-General of the International Atomic Energy Agency. From that date, started a most cherished personal friendship and one which transformed my life.

One consequence of the 1958 conference was that the Pakistan Government became interested in atomic energy. Pakistan has no oil, little gas, some hydro-potential. Pakistan needed atomic energy. In 1958, President Ayub Khan assumed power; I was recalled to Pakistan and asked to help with the creation of an Atomic Energy Commission.

We decided that in the absence of any other scientific organisation in the country, it was our mandate to create research teams and research institutes in all fields of national endeavour – agriculture, health, besides an atomic industry. For this and to fulfil the needs of Pakistan universities, we must train in the great institutions of the world, mathematicians, chemists, physicists and agriculturists.

We instituted a training programme for scientific manpower within our meagre resources. I say meagre, because at its peak, the total research expenditure in all universities and all research establishments in Pakistan never exceeded 4 million dollars – a sum which you in Sweden spend on one department of

physics in one university. With these meagre outlays, it was clearly impossible for Pakistan science to achieve any semblance of excellence. For ending the isolation of Pakistan science – the problem I had faced – we would still depend on international help.

For mobilising this help, an opportunity came in 1960 when I was fortunate to represent Pakistan at the General Conference of the International Atomic Energy Agency in Vienna. I suggested at this conference that the international scientific community represented through the scientific agencies of the United Nations organisation should accept as one of its responsibilities the caring for its deprived members – that there should be set up a network of first-rate international centres – in various pure and applied disciplines of science and technology which should offer their facilities principally to short-term senior visitors from developing countries. I envisaged a system of associateships available at these centres – through which top scholars from developing countries would be given long-term – five years – appointments enabling them to spend three months of their summer vacation working together with their peers from developed countries at these centres, recharging their batteries and taking back with them newer ideas, newer techniques, newer impetus. This would end the isolation which, for example, I had suffered and which, in my view, was the principal cause of brain drain of scientists – in contrast to the brain drain of doctors or engineers.

In 1961, the values of high level scientific and technological contacts were rather strikingly brought home to us in Pakistan. Pakistan had inherited from the 19th century one of the most extensive network of irrigation canals – some 10,000 miles long – irrigating 23 million acres of land. Some of these canals were as large as the Colorado River. They were carefully designed as to width, depth and slope in such a way that silty water moved just fast enough so that it neither eroded their beds nor choked them by depositing sediment.

But in 1961 something had gone grievously wrong with the system. After a few decades of operation, the canal network slowly began to stifle the very fertility it was meant to create by spreading the blight of water-logging and salinity in areas through which the canals passed. One million acres of land were passing out of cultivation every year during 1950 to 1960.

In 1961, Professor J. Wiesner, President Kennedy's Science Adviser, assembled a team of university scientists, hydrologists, agriculturists and engineers, led by Roger Revelle to advise on this problem of water-logging and salinity. This team suggested continuous pumping out of saline water to lower the water table, but with the important caveat that the pumping operation must be simultaneous over a contiguous area as large as a million acres – otherwise the quantity of water seeping in from the periphery would exceed the quantities pumped out. Pumping had been tried on parcels of land smaller than one million acres, but proved ineffective. Some of you may recall that Blackett during the last war was called upon to suggest to the British Admiralty whether merchant ships should cross the Atlantic in a few large convoys or many small ones – given that the number of available destroyers protecting against enemy submarines was fixed. Noting that ratio of area to circumference maximises with large radius, Blackett had suggested fewer large convoys rather than many small ones. Revelle's team's suggestion for Pakistan was a remark equally simple and it equally simply worked.

My next involvement with the United Nations system – and also the first disenchantment with the establishments representing their countries at this forum – came in 1962 when Dag Hammarskjöld projected a United Nations Conference to be held the following year, on Science and Technology. He had the vision of transforming the developing world – through technological projects like the one I have just mentioned. I had the privilege of a long interview with Dag – the only time I met him – and to share his semimystical reverence for what science and technology – if applied meaningfully – could achieve for the poor. He recognised clearly that this needed first and foremost investment, even if relevant technology was available. Much more even than the leaders of the developing world, he recognised that it was important to establish an indigenous scientific capacity in developing countries for research and development. This was needed, at the very least, to achieve an awareness of the significant development of world science and technology, an awareness which would enable a country to select and negotiate the purchase and ensure the effective assimilation of technology which its economic and social objectives required. He recognised that it is not just know-how which the developing countries need; it is also the *know-why*, if technological

development was to be a graft which should take in the poorer world.

The conference proposed by Hammarskjöld was held in 1963, unfortunately after his tragic death. We, from the developing countries, proposed the creation of a World Science and Technology Agency – a Technical Development Authority, backed by an international bank for technological development. Besides strengthening indigenous science in developing countries, the Authority would have acted as a planning and programming body which would carry out feasibility studies, devise programmes and arrange their implementation. Being a United Nations organisation it would associate with its work and give maturity to local scientific and technological organisations and talent, giving them training and intimate knowledge of the complex new techniques. Its very existence would have emphasised what the planning economist so often forgets – that the modern world and its problems are a creation of modern science and technology.

We proposed this; we lobbied for this, but we met with a complete blank wall of incomprehension – or worse – from the delegates from the industrialised countries – who, by and large, opposed the idea of any such Science and Technology Agency. It seemed that they preferred the scientific and technological effort of the United Nations to remain weak and fragmented with the system. There appeared no desire on their part to share technology with the developing world except through the existing system of licensing, operating in the manner I have described earlier in the context of Pakistan and the story of penicillin manufacture. The net legacy of this conference was the creation of an eighteen-man Advisory Committee on Science and Technology. We met for eleven years – twice a year; after eleven years labour, we have recommended yet another United Nations Conference on Science and Technology to be held in 1978, this to meet and create the same Science and Technology Development Agency we proposed fifteen years ago. This time we are likely to get this because Dr. Kissinger gave the proposed Conference his blessing three weeks ago.

I was meeting the same incomprehension in respect of my second suggestion at the forum of the IAEA regarding the idea of the creation of a Theoretical Physics Centre, particularly from some of the countries where theoretical

physics in fact flourishes. One delegate went as far as to say: "Theoretical physics is the Rolls-Royce of sciences - what the developing countries want is nothing more than bullock-carts". To him a community of 25 physicists and 15 mathematicians, all told, trained at a high level for a country like Pakistan with a population of 60 million, was simply 40 men wasted. That these were the men responsible for all norms and all standards in the entire spectrum of Pakistan's education in physics and mathematics was totally irrelevant. He was himself an economist, who had wandered into a scientific organisation like the IAEA. He could fully understand that we needed more high level economists, but physicists and mathematicians – that was wasteful luxury.

For the first time, it also began to be borne in upon me, how weak the United Nations system really was in terms of resources. Even today, 12 years later, the United Nations family has miniscule resources. Let me give you the figures (*Table I*).

Table I

## Budget Figures (in millions US\$)

	1975	1976
UN	540	620
UNEP	6	6
UNIDO	31	45
IAEA	32	37
WHO	115	125
UNESCO	255 (including 100 from UNDP)	
ILO	94	135
FAO	117	unavailable
ICAO	12	13
IMCO	unavailable	11

The total of the funds within the United Nations system for development do not add up to the funds available, for example, to the Ford Foundation – and this for service to 140 nations of whom 82 are desperately poor. The United

Nations was created as a community of equal nations – but some were more equal than others. It was financially weak because the rich nations would not contribute to its revenues; it was functionally weak because the powerful nations respected its resolutions only when they were extensions of the decisions of their own foreign policies.

In 1964 when IAEA did agree to the physics centre, its Board voted as a sum of US\$ 55,000 to create an international centre. Fortunately, the Government of Italy came through with an annual grant of US\$ 350,000 and the Centre was set up in Trieste.

To complete the story of the Centre, it started operating in 1964. It is now co-sponsored by IAEA and UNESCO, together with UNDP, who both contribute around a quarter million dollars each; plus the Italian Government with a grant of US\$ 350,000 and CIDA with a grant of US\$ 100,000. During the 11 years of its existence so far, it has received some 6,000 senior physicists from 90 countries – 4,000 of them from 65 developing countries. It has truly created something of a revolution so far as the studies of physics are concerned, so far as the developing world is concerned. Over the years it has tended more and more to emphasise technology transfer in physics. In this, we have particularly been helped by a Solid State Committee headed by Professor J. Ziman of Bristol and Professor S. Lundqvist of Chalmers in Gothenburg. Two weeks ago, we inaugurated the first ever extended three-month Course on the Physics of Oceans and Atmosphere attended by some 60 senior physicists, meteorologists and ocean-scientists from some 30 developing countries. The Centre, however, still remains a singularity – the one isolated Centre within the United Nations family of its kind in the entire spectrum of advanced scientific knowledge.

After 1963, the disillusionment with the existing international order came fast. You know the history of this decade as well as I do. President Kennedy with whom, rightly or wrongly, the liberal aspirations – also about world development – got linked was assassinated.

Around 1968, was the beginning of the student revolt and the realisation that the environment was being wrecked. I felt then and still feel – and this is why.

I am speaking to you today – that the developing world lost a great moment, lost a great potential alliance, a great potential source of strength when the protesting energy of world youth concentrated on the one issue of environment and did not espouse at the same time the more embracing cause of world development.

In between these years came the repeated failure of UNCTAD conferences convened to propose a redress for relatively ever-falling commodity prices. It is good to be reminded today that the price of petroleum fell decisively between 1950 and 1970 – down to one dollar a barrel, stimulating a growth in energy use of between 6% to 11%. The reception of UNCTAD's proposals – its fervent appeals for some stability and indexation of commodity prices – were received with derisory scorn, typified even today by the influential London *Economist* writing in its issue of 30 August this year on the eve of the United Nations Conference, "The notion that the price of each commodity can be tied, not to the demand for it, but to the average rise in the price of manufactured goods, is a proposal to try to repeal, by some conference fiat, the Laws of Supply and Demand. The industrial countries should simply refuse any concessions to this proposal". And this in a year which saw the index of manufactures' prices go up to 140, while commodity price index hovered around 114. Thus, in this one year alone, the poor have subsidised the welfare economies of the rich to the extent of 26% of their earnings.

In 1972 came the great Conference on Environment in Stockholm. It was significant not just for pinpointing that the environment was being wrecked and that some countries were contributing more than their fair share towards wrecking it. Even more important, it thrust into prominence the interdependence of the human community in solving the issues raised.

In 1972 came also the Club of Rome report on Outer Limits to Growth – with the thesis that world resources are finite and simply could not sustain infinite growth of industrialised economies. It is not well known that the poor countries had received a sharp reminder of this – as early as mid-1972 – in the form of a precipitous doubling of the price of wheat. This had happened because the failure of the crops in USSR made them buy 30 million tons of grain, nearly exhausting the world grain reserves. This was one of the

contributory causes of the threefold increases in oil prices; followed by yet another doubling of grain prices. Add to this the waning of the resource transfers of foreign aid programmes – the one collective commitment of the western countries - and you can understand the origins of the short-term crisis – the financial bankruptcy of poor humanity – with which I started my lecture.

To complete the story of foreign aid, the 17 richest nations allocated 0.3% of their GNP to overseas development last year, compared with 0.52% in 1960. While Sweden generously earmarked 0.72%, UK and USA provided 0.30% and 0.25% respectively. The World bank estimates that by 1980 the average of the 17 countries will be 0.28% and of US 0.18%. Contrast this with the US contribution at the beginning of the Marshall plans of 2.79% of GNP. Ministries in rich countries usually dismiss as unrealistic the United Nations target allocating 0.7% of their GNP to aid. Yet this target could probably be reached in the second half of this decade if they merely devoted 2% of the increased wealth – the US\$ 1,000 per capita growth I spoke before – which is expected to accrue to the industrialised nations in the next few years. At the United Nations Conference just concluded, EEC ministers did announce their readiness to try to meet the 0.7% target in 1980, though unfortunately, UK and USA expressed reservations.

Realising these stark facts, and realising that the developed world was unlikely to produce a Messiah – or even a Keynes – who would preach social justice between nation and nation, the developing countries decided in 1974 to use the forum of the United Nations for calling for a New International Economic Order.

### **The New International Economic Order**

What is the International Economic Order? The Rio Declaration, perhaps somewhat more radical than the United Nations Resolution, starts with the preamble: "Developed countries – by and large – have shown remarkable reluctance to initiate and support change. Having derived much of their wealth from cheap resources and raw materials of developing countries, they still

refuse to give access to their markets to the Third World. They refuse to recognise the inevitability of modifying their life styles, and scale and patterns of consumption, the maintenance of which requires a disproportionate share of world resources. They have used the power provided by science and technology to pursue policies shaped by selfish interests over the world's oceans, and they are squandering a vast fraction of mankind's resources, in scientific manpower as well as materials, in stockpiling of weapons of mass destruction". The document then goes on to say that "The struggle of the Third World is for *Economic Liberation*, greater equality of opportunity and securing of right to sit around the bargaining tables as equals with a redistribution of *future growth opportunities*. In the last analysis, we must look on the demand for the New International Economic Order as a part of a historical process, as a movement, to be achieved over time".

The United Nations Resolution on the New Order is perhaps somewhat more muted; it starts with a call for a commitment from mankind for the banishment of poverty and prevailing disparities; it calls for a just and equitable relationship between prices of raw materials and manufactured goods; it calls for access to the achievements of modern science and technology; it calls for an end to wasteful consumption – particularly in respect of food and expenditure on armaments.

In order to see how the ideals expressed in the United Nations Resolutions are carried out into realities it is perhaps worthwhile to consider food and military expenditures in somewhat greater detail.

## Food

In November 1974, the United Nations convened a Conference in Rome on Food. This conference adopted the following declaration: "Within a decade no child will go to bed hungry and no family will fear for its next day's bread and no human being's future will be stunted by malnutrition". To achieve this target, a World Food Council was set up, with the minimum target of distributing 10 million tons of grain a year as food aid, and achieving average

3.6% increases per year in food production by poor countries, through an international provision of agricultural inputs.

On 29 June 1975, the *London Times* reported "The World Food Council ended its inaugural meeting here in Rome at 2.00 a.m. yesterday. It was saved from being an obvious farce and a failure only by some quick facesaving footwork by western diplomats. France, Germany and Italy have so far refused to endorse an increase in EEC's food aid from 1.3 million tons to 1.6 million tons. This was bitterly attacked in Rome, not the least by UK which threatened to increase its own bilateral aid if the insensitivity of its partners continued. The commitment to 10 million tons – even though well short of food aid levels of 1960 – has still not been reached".

Is there a real absolute overall shortage of food in the world, which makes the contribution of this 10 million tons impossible – and with this the inevitability of starvation in poor countries? The answer is NO.

It should be emphasised again and again that the grain is physically available. It is simply being consumed by well-fed people. Since 1965, the richer nations have added 350 pounds per head to their annual diets, largely in the form of beef and poultry. This was stimulated by a special pricing policy at a time when US surpluses of food grains were running in excess of world demand by some 60 million tons a year, in spite of a curtailment in area cropped, by one-half. This is very nearly the equivalent of an Indian's total diet for a whole year. Few will maintain that the industrialised countries were undernourished in 1965. A cut in consumption, for example the suggested equivalent of one hamburger a week, could provide all the grain needed to support a population as large as one-third of the Indian subcontinent.

Let us next consider the question of armaments; and arms reduction. In 1973 the world military expenditure came to 245 billion dollars. This sum is 163 times greater than that spent on international co-operation for peace and development through the United Nations system; (this sum stands at approximately 1.5 billion, excluding the World Bank). The superpowers spent 50% of these 245 billion dollars, while another 30% was spent by military alliances. The share of the Third World also, unfortunately, increased between

1955 to 1975 from 6% to 17% - and we are not entirely blameless. The world military expenditures are now greater than the GNP of all Africa and all of South Asia. During the two decades, 1960's and 1970's the total military expenditure was US\$ 4,000 billion, which is greater than all goods and services produced by all mankind in one year.

When we consider the situation with materials and men, the situation regarding expenditures appears even grimmer. Close to 7% of all raw materials in the richer countries are consumed by the armament industry. This includes oil, iron, tin, zinc, copper and bauxite. It is estimated that about 50 million people are employed for military purposes in armed forces and defence activities. Close to half a million scientists and engineers, almost half of the world's scientific and technological manpower, is devoted to military research and development, costing between US\$ 20 to US\$ 25 billion. These sums represent 40% of all public and private research and development expenditure mankind appropriates. Contrast this with the half million dollars we have been able, after five years of continuous effort, to collect for the International Foundation for Science whose first General Assembly is taking place in Stockholm today. The situation is clear, it is not the poor countries who jeopardise the global balances, it is the rich and their rivalries and their desire to hold monopoly military power.

To summarise, the demand for a New International Order is a demand of a basic minimum standard of living and of economic security for all citizens; a deliberate policy of development and re-distribution to achieve this. Just as on a national scale the achievement of the social and economic goals is left not entirely to individual effort and initiative but is prompted actively by the combined efforts of the entire community, so also on an international level the aspirations of the nations of the world in the social and economic sphere should be made easier to achieve by a concentrated effort of the world community as a whole - by the Family of Man, acting as a whole.

What the developing countries really want on a psychological plane is to regain their sense of dignity and self-respect which they enjoyed for long centuries and which they lost only during the brief period of western domination; a domination based essentially on an industrial and technological

revolution which is hardly two centuries old. The fact that country after country in all parts of the world has successively and successfully mastered technology is also not overlooked by those who are still left behind. What the developing countries are asking for is not unlimited migration, to the open, uncultivated, under-utilised areas of this globe; they have never asked for transfer of income, wealth and resources at any exorbitant level. It is rather a meaningful sharing of technology and equitable trade they are really after.

Perhaps the time has come for supplementing national transfer with some international sources of revenues - the international commons, taxed for the benefit of the poorest strata of poor countries. This would be a first step towards the establishment of an international taxation system and an international treasury aimed at providing automatic transfers of resources for development assistance. I remember this suggestion being voiced by Linus Pauling at the 1969 Nobel Symposium on the Place of Value in a World of Facts, held in Stockholm in 1969 and the somewhat cool reception the idea received. It appeared too radical at that time. But perhaps its time has come; perhaps one may start with an international commons provided by resources of world oceans, the one resource not yet finally carved out among nation states.

**Table II**

Grain Surpluses and Deficits for 1973(in million tons of grains)	
North America	+ 91
Latin America	- 3
Asia	- 43
Africa	- 5
East Europe	- 27
West Europe	- 19

The 138-nation Law of the Sea Conference held in Caracas, Venezuela in 1974 has negotiated at its last session in Geneva a single informal negotiating text which unfortunately is still subject to amendment. The comprehensive treaty envisaged for 1975 has been called the most vital document the United Nations will produce, since 1945. The treaty envisages extension of territorial waters from 3 to 12 nautical miles, an exclusive economic zone under coastal state jurisdiction extending up to 200 miles, plus 200 metres depth whichever is farther. This, if finally approved, would be an unmitigated disaster, even though some developing countries will benefit from this. The sea bed contains perhaps 1,500 billion barrels of petroleum; at present some 15% of the world's oil and gas comes from the oceans, but they contain perhaps the major portion of future oil potential. Some 18 billion dollars of high-protein fish are caught annually and then there is the possibility of easy dredging from the North Pacific deep ocean-floor of some 400 million tons of copper, manganese, nickel and cobalt nodules every year. Compare this 400 million tons with 10 million of these minerals consumed annually now. The exciting thing about these nodules at the ocean bed is that they obligingly renew themselves all the time – either because they are organic materials like coral or because some obscure process of ionisation is at work at the sea bed.

The effect of the proposed treaty will be to place 62% of the sea bed oil under the jurisdiction of 10 of the most fortunate coastal states - most of which have per capita incomes already exceeding US\$ 1,000 - while 51 countries with little or no continental shelf will get only 1%. I am no legal expert, but to any internationalist it is clear that what is truly needed is the replacement of the outmoded concept of national sovereignty by a concept of "functional sovereignty" which permits the interweaving of national and international jurisdiction within the same territorial space. At present, the only agreement which has been reached envisages that there will be an International Sea Bed Resources Authority which will provide environmental protection over deep sea mining and that it might be allocated revenues collected directly from production of deep sea minerals. However, regarding the more immediate resource, oil, there is still a discussion going on, if royalty revenues from sea bed oil may be pooled through an international fund, to be used primarily for

developing countries. Canada has suggested collection of 1% of sea bed oil revenue. The US Government suggests a small percentage of revenue from oil *beyond* 200 miles limit. But there is no forceful voice, yet, calling for a significant reapportioning of these new windfalls such that a meaningful international commons is paid - for global development.

This trend of thinking must be reversed. Substantial revenues from sea bed oil could go to the international community. Twenty percent of these could provide a sum for developing countries of up to as much as 6-12 billion dollars a year. The International Sea Bed Resources Authority could become a model for world institutions, dealing with arms control, disarmament or global resource management. Geneva 1975 may be the last and the only opportunity of ensuring that the concept of "common heritage of mankind" becomes and remains – not just an empty concept.

I should perhaps conclude by telling you what actually happened at the United Nations Conference. What is it that has been achieved? Dr. Henry Kissinger, alive to the danger of a confrontation more virulent, more destructive than any cold war, urged the recognition that if there was no action on the demands from the poor, "Over the remainder of this century, ... the division of the planet between north and south could become as grim as the darkest days of cold war. We would enter an age of festering resentment, of a resort to economic warfare, a hardening of new blocks, the undermining of co-operation, the erosion of international institutions - and failed development".

Dr. Kissinger and the US have promised a multiplicity of institutions to meet the needs of co-operative world development. Two of these are:

- (i) A "Development Security Facility" to stabilise prices of commodities against crude cycles of export earnings though "indexing" was decisively ruled out;
- (ii) Measures to improve access to capital technology and managerial skills – and in particular an International Energy Institute, an International Centre for Exchange of Technological Information and an international Industrialization Institute.

At long last the physicists we have trained at Trieste will find a rightful role in the development of their countries, though I do hope these new Centres do not suffer the frustrations which 11 years of running a United Nations institute have taught me to fear. In dealing with the United Nations one finds to one's frustration that the promises which one department of a national government makes of unheeded by the other departments of the same Government; that each department of each donor country wishes to investigate ab initio what the United Nations Centre is achieving. So far as Trieste is concerned, this year there have been five commissions reporting on the Centre; there will be two more before the year ends. And this happens every year. The point is that the United Nations funds are extremely limited, the organisation is an orphan and the energy needed to keep any initiative alive through the United Nations is often out of all proportion to the results achieved.

To come back to the Conference, regretfully there was no new commitment of resource transfers - these new institutions will presumably divide the old cake differently; their very multiplicity will unfortunately not make any realisation of the ideals of world development any easier.

I come back to you – my audience – you are our only hope to realise the ideals I spoke of into realities in a meaningful manner. For make no mistake, for world development much more sacrifice will be called for and will have to be made. But I am a believer in man's moral state and I shall conclude with the words of a mystic who expressed the international ideal of Family of Man in the 17th century, John Donne: "No man is an island, entire of itself; every man is a piece of the continent, a part of the main; if a clod be washed away by the sea, Europe is the less, as well as if a promontory were, as well as if a manor of thy friends or of thine own were; any man's death diminishes me, because I am involved in mankind; and therefore never send to know for whom the bell tolls; it tolls for thee".

# APPENDICES

# I. Foundations for Sciences in Islam

*Enclosing the Memorandum on the Creation of an Islamic Science Foundation, 1973.*

Science flourishes only if it is supported by stable and independent sources of funds. It is a truism accepted in the West that society should provide as many *different* channels for the funding of science as possible. The wide variety of such funding sources is considered essential in order to ensure that if one source does not accept support, there is the possibility of another source being open. This is important for the acceptance of new, untried ideas, which may not appeal to all selectors. Furthermore, the different sources can each develop expertise for evaluating and judging projects in one or more speciality. Thus, if there are a multiplicity of foundations, one of these may specialise in agricultural projects, another on projects in energy, yet another on projects relating to training of scientists and so on.

I had the privilege of writing the enclosed memorandum on the creation of an Islamic Science Foundation in 1973. This project was approved by the Islamic Conference and the Foundation has now been created as an Islamic Intergovernmental Agency. The original memorandum written at a time (July 1973) when the export income of some of the Muslim countries was much smaller than it is now, suggested a capital of one billion dollars with income of the order of one (sixty or seventy) million dollars annually. In this way this Foundation - covering all islamic countries - would marshal funds equivalent to just the Ford Foundation in the U.S.A., so far as annual income is concerned.

I understand that the present plans are to give the newly created Islamic Science Foundation a starting annual income of 50 million dollars, both for capital formation and for current expenditure on sciences. Clearly this is far short of what was envisaged, in view of the vast needs and the research areas to be covered.

Considering the enormous leeway we have to make in the development of sciences and technology and to ensure the multiplicity of sources for funding of scientific research I have mentioned before, I wish to suggest that the Gulf countries, besides setting up science foundations of their own (Kuwait and Saudi Arabia have made a start), may consider the creation of a *Gulf Science Foundation* which should fund scientific research projects and which should be open to all Arab-Islamic countries. The international norms are 1-2% of GNP devoted annually to these projects. I would like to suggest similar norms to be accepted (for example, 1-2% of export earning) giving the Foundation an eventual annual income of 300-400 million dollars. The system of giving grants may follow the normal international pattern. This, together with some of the projects which the Foundation may support and the modalities it may adopt are illustrated in the accompanying document drawn up for the Islamic Science Foundation. As suggested above, the Islamic Science Foundation and the Gulf Science Foundation, can each demarcate broad areas of specialisation (for example biology and agriculture for one Foundation, physical sciences for the other). In any case, the Arab-Islamic world is hungry for funds for science and even the combined resources of these two foundations are not likely to suffice - the needs are simply so great.

## Islamic Science Foundation

1. This is a proposal for the creation of a Foundation, by Islamic countries, with the objective of promotion of science and technology at an advanced level. The Foundation (working in conjunction with the Islamic Conference) would be sponsored by the Muslim countries, and operate within these, with an endowment fund of \$ 1,000 million and a projected annual income of around \$ 60 - \$ 70 million. The Foundation will be non-political, purely scientific, and run by eminent men of science and technology from the Muslim world.

## 2. Need

No Muslim country, in the Middle East, in the Far East or Africa possesses

high-level scientific and technological competence attaining to any international levels in quality. The major reason is the persistent neglect by Governments and society in recent times in acquiring of such competence. In relation to international norms (around .3% of economically active manpower engaged in higher scientific, medical and technological pursuits, with around 1% of GNP spent on these) the norms reached in the Islamic world are one-tenth of what one should expect for a modern society.

### **3. *Objectives of the Foundation***

It is suggested that a well-endowed Islamic Science Foundation be created with two objectives; *building up of high level scientific personnel and building up of scientific institutions*. In pursuit of these objectives:

- (a) The Foundation will create *new communities* of scientists in disciplines where none exist. It will strengthen those communities which do exist. This will be done in a systematic manner, with the urgency of a crash programme.
- (b) The Foundation will help in building up and in strengthening *institutions* for advanced scientific research at international level, both in pure and applied fields, relevant to the needs of the Muslim countries and their development.

The emphasis of the Foundation's work would lie in building up sciences to *international standards of quality and attainment*. Of the two objectives listed above, the building up of high level scientific personnel will receive higher priority in the first stages of the Foundation's work.

### **4. *Programme***

In pursuance of its twin objectives (a) of building up high-level scientific manpower in a systematic manner, and (b) of employing this manpower for advanced work for the betterment and strength of Islamic societies the Foundation will pursue the following programme:

- (a) *Building up of Scientific Communities*
- (i) Scholars will be sponsored by the Foundation to acquire knowledge of advanced sciences, wherever available, in areas where gaps exist and where there are no existing leaders of sciences. After their return to their countries, the Foundation will help them to continue with their work. Funds of the order of \$ 10 million would support some 4,000 scholars annually while they are receiving advanced training, and support around 1,000 scholars and the needed facilities on their return.
- (ii) Programmes will be organized around existing scientific leaders in order to increase high-level scientific manpower. For this purpose, contracts will be awarded to University departments to strengthen their work in selected fields. *Quality* of the University faculties will be the criterion for the award of these contracts. Funds to the total of around \$ 15 million may be spent annually for these contracts.
- (iii) *Contact of scholars from the Islamic world with the world scientific community.* Existing science in Muslim countries is weak because of its isolation. There are no contacts between scholars in Muslim countries and the world scientific community, principally on account of distance. Science thrives on the interchange of ideas and on continuous criticism. In countries with no international scientific contacts, science ossifies and dies. The Foundation will endeavour to change this. This will entail frequent two-way visits of fellows and scholars, and holding of international symposia and conferences. Funds of the order of around \$ 5 million will subsidise some 3,000 visits a year of around two months' duration. This, spread over around 10 sciences and over 15 countries, is about 20 visits a year from any one country in any one science.
- (b) *Sponsoring of Relevant Applied Research*
- The Foundation may spend around \$ 25 million for the strengthening of existing, and the creation of new research institutes on problems of development in the Middle East and the Islamic world. These new institutes of international level and standing would be devoted to research in problems of

health, technology (including petroleum technology), agricultural techniques and water resources. These institutes may also become units of the United Nations University system in order to attain international standards of quality and achievement through contact with the international community. (A successful institute like the International Rice Institute in the Philippines costs about \$ 5 - \$ 6 million to create, and about the same amount to run at an international level.)

(c) The Foundation may spend around \$ 5 million in making the general population of Islamic countries technologically and scientifically minded. This will be achieved through instruction using mass media, through scientific museums, libraries and exhibitions, and through the award of prizes for discoveries and inventions. An appreciation of science and technology by the masses is crucial if there is to be a real impact of science and technology.

(d) The Foundation will help with the task of modernising syllabi for science and technology at the High School as well as University levels.

### **5. *Functioning of the Foundation***

- (a) The Foundation will be open to sponsorship by all Islamic countries which are members of the Islamic Conference.
- (b) The Foundation will have its headquarters office at the seat of the Islamic Conference. In order to retain active and continuous contact with the research centres and projects it endows, it may set up subsidiary offices as well as employ scientific representatives, resident or at large.
- (c) The Board of Trustees of the Foundation, which will be responsible for liaison with the Governments, will consist of representatives of the Governments, preferably scientists. The endowment fund of the Foundation will be vested in the name of the Board of Trustees.
- (d) There will be an Executive Council of the Foundation which will consist of scientists of eminence from the Muslim countries. The first Council and its Chairman (who will also be the Chief Executive of the

Foundation) will be appointed by the Board of Trustees for a five-year term. This Council will decide on the Foundation's scientific policies, the expenditure of the funds, their disbursement and their administration. The work of the Foundation and the Executive Council will be free from political interference. The Board of Trustees, through the statutes, will be charged with the responsibility of ensuring this.

- (c) The Foundation will have the legal status of a registered non-profit making body and would have a tax-free status both in respect of its endowments as well as emoluments of its staff.
- (f) The Foundation will build up links with the United Nations, UNESCO and the United Nations University system, with the status of a non-Governmental organization (NGO).

#### 6. *Financing of the Foundation*

- (a) It is envisaged that the sponsoring countries would pledge themselves to provide the endowment fund of \$ 1,000 million in four yearly instalments.
- (b) The proportion of the endowment fund to be contributed by each sponsoring country will be a fixed fraction of the export earnings of the country. The 1972 schedule of export earnings for the Muslim countries is appended. In future years these earnings are expected to increase. However, even at the 1972 level of 25 billion dollars per year, a contribution of less than one per cent per country per year would suffice to build up the initial endowment capital of one billion dollars over four years.

2 July 1973

1972 Merchandise Exports <sup>1</sup> of Moslem Countries (In millions of U.S. \$)			
Afghanistan	84 ***	Mauritania	101 **
Algeria	1,009	Morocco	498
Bahrain	267 *	Nigeria	1,811
Bangladesh	270 ****	Oman	147
Chad	44 **	Pakistan	550 ****
Egypt	789	Qatar	275 **
Gabon	174 **	Saudi Arabia	3,845
Indonesia	2,061	Sierra Leone	100
Iran	2,642	Somalia	34
Iraq	1,538	Sudan	329
Jordan	32	Syria	195
Kuwait	2,407	Trucial States	790
Lebanon	242	Tunisia	219
Libya	2,863	Turkey	882
Malaysia	1,636	Yemen (People's Republic)	105
<i>Total</i>			25,939

<sup>1</sup> Except where otherwise indicated by \* for 1971, \*\* for 1970, \*\*\* for 1971/72 and \*\*\*\* for 1972/73.

NOTE: Since 1974 the export earnings of oil-producing countries have gone up by a factor of around ten.

## II. Specialisation in Building of Third World Science and Education

February 1985

1. *"To those people in the huts and villages of half the globe, struggling to break the bonds of mass misery, we pledge our best efforts to help them help themselves for whatever period is required, ... not because we seek their votes, but because it is right.*

*"To that World Assembly of sovereign states, the United Nations, ... we renew our pledge of support ... to strengthen its shield of the new and the weak and to enlarge the area in which its writ may run.*

*"Now the trumpet summons us again, ... (to) ... a struggle against the common enemies of man: tyranny, poverty, disease and war itself. Can we forge against these enemies a grand and global alliance, North and South, East and West, that can assure a more fruitful life for all mankind? Will you join in that historic effort?"*

These are quotes from President John F. Kennedy's inauguration address on 20 January 1961. A quarter of a century later, these sound like a voice from another planet.

In his global concern with mass misery and poverty (both in the developed and the developing countries) as well as in assigning a role to cooperative approach through the United Nations for resolution of these problems, John Kennedy was giving an expression to mankind's moral ideals.

2. The diminution in the concern for the Third World on the part of the leaders of major industrialised powers contrasts sharply with the genuine anxiety over and active sympathy for hunger and poverty among the peoples of their countries. This was demonstrated by the generous response in Europe and

North America to Geldof's appeal for funds to alleviate famine in Africa. And it was touching to note that during this Christmas, school children in Great Britain raised over 1 million pounds for African children. There is no doubt that the people in the Western world are willing and able to respond to the Third World causes. The global vision and concern evinced by President Kennedy may not be on the agenda of the present generation of our leaders, but the compassion among their people is undiminished.

3 . Among the casualties of this dimming of the global vision have been Third World science and education. Although bilateral programmes exist for help, there is yet no visible dent in the basic areas of education, of technology training, of science transfer or of scientific research.

The tasks which could be undertaken are well known, e.g. the building up of literacy, the building up of infrastructure for science teaching as well as for scientific research, the need for building up of libraries as well as of laboratories and, above all, of building up indigenous scientific communities. So far as the aid agencies of developed countries are concerned, these tasks are new. It is now abundantly clear that there is no real substitute for international action and international modalities.

4 . However, given the world as it is today, we need to combine the best of bilateral help with the multinational approaches. One proposal which may be considered in this context is that of specialisation. Could, for example, a consortium of universities in the US and UK be helped by their governments and encouraged to take care of University Science, in all those developing countries which desire this? Could one envisage the USSR taking care of primary, secondary and vocational education? Could the Netherlands and Belgium look after the building up of libraries and laboratories? Could Germany and Japan look after technical education on all levels? Could Scandinavia look after the scientific aspects of ecology? Could Switzerland and Austria (with their well-known pharmaceutical expertise) look after medical

education? Could Italy with its experience of setting up International Centres in Physics and Biotechnology, look after the creation of similar institutions in all disciplines of science in concert with developing countries? Could the US, Canada, Australia and New Zealand look after education for agriculture and education for prospecting? Could France and Spain translate these actions for the French and Spanish speaking developing countries if desired by them? This is merely an illustration of what a possible division of the relevant tasks could be. Eventually, of course, these suggestions would have to be tailored and modified when detailed projects are elaborated.

What I have in mind is something patterned along the lines of the success which India achieved in the decade of the sixties when it created four Indian Institutes of Technology. The one in Kanpur was created by a US consortium of universities which helped to raise and furnish it, besides supplying the higher cadres of teaching staff for a number of years. The one in Delhi was helped by a UK consortium of British universities; the one in Bombay was set up by the USSR and the one in Madras by the Federal Republic of Germany. Each nation helped to build up the institute under Indian auspices, contributed staff and left behind a tradition in teaching and research which has continued even after the original contracts have expired. There was a healthy rivalry between the donor nations vying with each other; this guaranteed the excellence and standards of quality. What I envisage in the proposal above is something like this except that it is to be carried out on a much wider canvas. One would hope that by the year 2000, if the plans are drawn up now, many of the objectives I have mentioned will have been achieved.

5. I have spoken of subject-wise specialisation. Take education as an example; a plan of this type will reduce costs in the standardised building of schools, in equipping them, in teacher training and in providing text books for schools. Carrying out the projects for the entire world will mean that this will be done less expensively than tailoring a system to a single nation.

But in all these proposals it is essential that the relevant educational or scientific communities of the developed countries should be involved through a

system of consortia, through a direct twinning of scientific and research institutes or through similar modalities.

In this context, forgive me for thinking along the following terms: In addition to funds made available through the official aid agencies, the educational and scientific institutions in developed countries may consider contributing in kind in their own ways, according to the norms of the well-known United Nations formula, whereby most developed countries have pledged to donate .7 to 1% of their GNP resources for world development. In the end, it is a moral issue whether the better-off segments of the educational and scientific communities should be willing to look after their own deserving but deprived colleagues, helping them with a similar formula from their own resources - not only materially, but also joining them in their battle to secure recognition within their own countries as valid professionals who are important to development.

6 . Where, in all this, do the multi-national aspects come in? They come in the following way: UNESCO, the Third World Academy of Sciences, ICSU and similar bodies - could be asked to take care that this scheme works with requisite quality and *non-politically*. This last is crucial if we are to achieve an acceptance by the developing countries of the help received.

7 . I sometimes wonder if the diminution of multi-national help has come about principally because of escalating defence expenditures? In this context, the following quote from another great visionary, President Dwight Eisenhower, may be relevant. Addressing the American Society of Newspaper Editors on 16 April, 1953 President Eisenhower spoke against the "military industrial complex". He said: "Every gun that is made, every warship launched, every rocket fired signifies, in the final sense, a *theft* from those who hunger and are not fed, those who are cold and are not clothed.

"This world in arms is not spending money alone.

"It is spending the sweat of its laborers, the genius of its scientists, the hopes of its children.

"The cost of one modern heavy bomber is this: a modern brick school in more than 30 cities.

"It is two electric power plants, each serving a town of 60,000 population.

"It is two fine, fully equipped hospitals.

"It is some 50 miles of concrete highway.

"We pay for a single fighter plane with half a million bushels of wheat.

"We pay for a single destroyer with new homes that could have housed more than 8000 people ...

"This is not a way of life at all, in any true sense. Under the cloud of threatening war, it is humanity hanging from a cross of iron."

8. "Cross of Iron!" Unfortunately, his words went unheeded both in the West and in the East, as well as by the (warring) nations of the Third World. Personally, I am a firm believer in man's moral state and I shall conclude with the words of a mystic who expressed the international ideal of the Family of Man in the 17th century: "No man is an island, entire of itself; every man is a piece of the continent, a part of the main; if a clod be washed away by the sea, Europe is the less, as well as if a promontory were, as well as if a manor of thy friends or of thine own were; any man's death diminishes me, because I am involved in mankind; and therefore never send to know for whom the bell tolls; it tolls for thee". – John Donne

### III. Towards Revitalizing UNESCO

*The following article on the United Nations Educational, Scientific and Cultural Organisation in Paris was written by Prof. Abdus Salam for the Higher Educational Supplement of "The Times" of London*

The Prophet-King Solomon said in the Bible, "Where there is no vision, men will perish."

1) UNESCO is potentially a great organisation. As a specialized agency of the United Nations, its mandate is to enhance science, education and culture in a *professional* fashion following a *Non-political, Non-bureaucratic approach*, in a spirit of *co-operation among all nations*, East and West, North and South.

Such a vision of UNESCO's professional role, especially in a world already with a population in excess of five billion, must be shared universally by the governments and the peoples of the rich industrialised countries as well as of the poor developing countries if the organisation is to work. This shared vision, and UNESCO's living up to it, should bring back the USA, Britain and Singapore to UNESCO.

2) At present, though, one hears rather frequently, comments critical of UNESCO. These stem from:

- Perception of UNESCO having strayed from its role as a specialized Agency concerned *professionally* with Science, Education and Culture; instead it has become active in areas of more proper concern to the United Nations itself;
- The fractionalization of its programme among a great number of small components incapable of making an appropriate impact;
- The low level of participation in its work of individual great men of Science, of men of Education and of men of Culture, and the consequent lack of "*hardness*" in its programme;
- The gradual deterioration of staff morale. Many well-qualified people have already left the Secretariat and the best of those remaining are very concerned;

- A heavy administrative bureaucracy established through the years with no systematic and effective efforts at reducing it, in the interest of a better programme with the funds saved.

On the positive side, however, one must note that:

- UNESCO exists in a generally ready-to-use form. Its functions as an inter-governmental organization - as an instrument for consultation, co-operation and joint action - cannot be duplicated elsewhere;
- UNESCO knows from long experience how to co-operate on programme activities with non-governmental organizations, national bureaucracies and other inter-governmental organizations; and
- It still retains an important nucleus of competent and dedicated staff.

UNESCO clearly needs to be revitalized if it is to perform appropriately the functions for which it was designed.

In this note, some suggestions are made to achieve this.

#### A. *In Sciences: two major tasks*

- 1) Enhance *global aspects* of Science, with the *fullest participation and involvement of the world's scientific community*.  
(The International Council of Scientific Unions (ICSU), together with a possible Federation of Academies of Sciences and National Research Councils (to be constituted) should play a leading role in this.)
- 2) Take active steps to close the *growing gap in hard sciences* between the industrialised and the developing countries. This, in my opinion, should be the single most important objective for UNESCO between now and the year 2000.

This task can be accomplished (1) by building up the scientific communities in the developing countries, (2) and by emphasising the role of the scientists as valid professionals in the development of their own countries. The accomplishment of these tasks will involve building up the infrastructure for sciences, including complete science libraries, and also the deployment of modern communication systems, for purposes of Science dissemination.

**B. In education:**

- 1) To enhance vastly the development of technical education and institutions plus vocational centres in those areas of the world where these are sorely lacking \*

**\* Concrete steps needed for Enhancement of Technical and Science Education**

- 1) After a period of compulsory lower-secondary education (which may finish at the age of 16 or so) most of the modern societies provide for two parallel educational systems. Using the U.K. terminology of the 1970's, these two systems may be called (1) the system of professional education ("blue collar" education) comprising technical, vocational, agricultural and commercial courses, and (2) the system of higher education ("white collar" education) comprising courses which lead on to the university level, in the sciences, engineering, medicine and the arts.

A major structural failing of the Third World educational system has been that, in general, no credible professional ("blue collar") system has developed. It is true that a half-hearted system of polytechnical institutions and vocational schools has been built up in recent years in a number of Third World countries, but this system, has had scant prestige attached to it. (As a general rule, such systems have been run by the Ministries of Labour and Employment, rather than the Ministries of Education.)

To see how inadequate such a system has been, one may recall that in industrialized countries the proportion of those enrolled for the two streams is of the order of 50:50. In the Third World, however, the proportion of the professional versus the university level (blue versus white collar) enrolment is normally of the order 10:90. This preponderance of the technologically illiterate is the major cause of unemployment and of the Third World's technical backwardness.

One of the main educational tasks before the Third World is to change this ratio of 10:90 to 50:50. In the conditions of today, the blue-collar "professional system" should be accorded equal status with the better-known "higher education system" and should include courses on modern materials' (including metal) fabrication, as well as courses on microelectronics.

One could go even further and include the subjects mentioned above, at the lower-secondary level so that every student is familiar with and able, at the least, to undertake materials' (and metal) fabrication, as well as electrical, automotive, or microelectronic repair-work.

- 2) The proportion of those following Science and Engineering versus those following the arts at the university level is of the order of 50:50 among industrialised nations. This is certainly not the case for most of the developing countries. One must aim at a 50:50 ratio for the developing countries also. This will need equipping the institutions of higher learning adequately.

- 2) In the industrialised countries to emphasise *global* concerns and *global* studies in the various areas of knowledge.
- 3) Equally, stronger efforts must be brought to bear to end the problem of illiteracy in regions where this phenomenon has been so persistent.
- 4) Wherever tertiary scientific institutions are lacking, but the primary and secondary levels are adequate, one might operate a *UNESCO University of Science and Technology*. This might offer post-graduate science degrees, particularly at the Ph.D. research level. Such a University would consist of a network of research centres located in different (including developing) parts of the world, encompassing (existing) first-class national as well as international centres.

### C. *Specialization*

In this context, one proposal which may be considered is that of specialization.

For example, under the aegis of a revitalised UNESCO, could a consortium of Universities in the U.S. and U.K., France and Spain, be helped by their Governments and encouraged to play a leading role in aiding *University Science* in all those developing countries which desire such help? Could one envisage the U.S.S.R. providing similar assistance in relation to *primary, secondary and vocational education*? Could the Netherlands and Belgium look after the building up of *libraries and laboratories*? Could Germany and Japan primarily look after *technical education* at all levels? Could the Scandinavian countries look after the *scientific aspects of ecology*? Could Switzerland and Austria (with their well-known pharmaceutical expertise) take over the fullest responsibility for *medical education*? Could Italy with its experience of setting up *International Centres in Physics and in Biotechnology*, look after the creation of similar institutions in these and other disciplines of science in concert with developing countries? Could the U.S., Canada, Australia and New Zealand look after *education for agriculture and education for prospecting*? Could France and Spain carry out all these actions for the *French and Spanish speaking developing countries* if desired by them?

This is merely an illustration of what a possible division of the relevant tasks could be. Eventually, of course, these suggestions would have to be tailored

and modified when detailed projects are elaborated. In this, one must not forget that (even though not affluent enough to contribute materially) countries like China, India, Brazil, Egypt, Yugoslavia and many others could make highly valued intellectual inputs to these specialized efforts. UNESCO's role would be advisory; so as to guarantee the requisite quality and non-political nature of the programmes.

*D. Programmes Implementation and Monitoring*

To achieve these goals, it will be necessary to maintain effective channels of communication with *all* Member States; to concentrate resources on those substantive areas for which the organisation is best suited, and to *maintain the lowest possible ratio of administration-to-programmes*. An efficiently managed Secretariat, staffed by competent and motivated individuals, is a *sine qua non* for effective performance and morale.

*E. UNESCO House at the Headquarters and Outside*

The UNESCO House at the Headquarters must become a House of Science, a House of Education and a House of Culture, receptive to new ideas, with a library of the top-most world standards. It should welcome the cream of the world's scientists, educationists and thinkers for weekly lectures and discussions, as well as for cultural manifestations from all nations. *It must not be a house for an entrenched bureaucracy.*

The UNESCO House outside the Headquarters should replicate these activities, with first class and complete libraries - at least for science journals.

*F. In culture*

Of all organizations on this globe, UNESCO is the one which is uniquely suited to emphasise the unity of science and culture. This would have an important dual effect: an increased understanding of the role of science in the lives of men and an increased understanding of the need and role of cultural values in a changing world.

These are just a few thoughts concerning the future role of UNESCO, which, in spite of its present difficulties, continues to personify mankind's vision towards furthering of Science, Education and Culture.

# BIODATA

# Biodata

## 1. ABDUS SALAM

Date of birth: 29 January 1926  
Place of birth: Jhang, Pakistan  
Nationality: Pakistani

## 2. Educational Career

Government College, Jhang and Lahore (1938-1946)	M.A. (Panjab University)
Foundation Scholar, St. John's College, Cambridge (1946-1949)	B.A. Honours Double first in Mathematics (Wrangler) and Physics
Cavendish Laboratory, Cambridge (1952)	Ph.D. in Theoretical Physics

Awarded Smith's Prize by the University  
of Cambridge for the most outstanding  
*pre-doctoral* contribution to physics (1950)

## 3. Appointments

(1951-54)	Professor, Government College, Lahore
(1951-54)	Head of the Mathematics Department of Panjab University, (Lahore)
(1954-56)	Lecturer, Cambridge University (Cambridge)
(1957- )	Professor of Theoretical Physics, London University, Imperial College (London)

- (1964- ) Founder and Director, International Centre for Theoretical Physics (Trieste)
- (1951-56) Elected Fellow, St. John's College (Cambridge)
- (1951) Member, Institute of Advanced Study (Princeton)
- (1971) Elected, Honorary Life Fellow, St. John's College (Cambridge)

#### **4. United Nations Assignments**

- (1955 and 1958) Scientific Secretary, Geneva Conferences on Peaceful Uses of Atomic Energy
- (1962-63) Elected Member of the Board of Governors, IAEA, Vienna
- (1964-75) Member, United Nations Advisory Committee on Science and Technology
- (1971-72) Elected Chairman, United Nations Advisory Committee on Science and Technology
- (1970-73) Member, United Nations Panel and Foundation Committee for the United Nations University
- (1981-83) Member, United Nations University Advisory Committee
- (1981-86) Member, Council, University for Peace (Costa Rica)
- (1981) Elected Chairman, UNESCO Advisory Panel on Science, Technology and Society

#### **5. Other Assignments**

- (1970) Member, Scientific Council, SIPRI (Stockholm International Peace Research Institute)
- (1972-78) Elected Vice Chairman, International Union of Pure and Applied Physics (IUPAP)
- (1983- ) Elected First President of the Third World Academy of Sciences
- (1983-86) Member of the CERN Scientific Policy Committee
- (1986- ) Member of the Board of Directors of the Beijir Institute of the Royal Swedish Academy of Sciences

## **6. Awards for Contributions to Physics**

- (1958) Hopkins Prize (Cambridge University) for the most outstanding contribution to physics during 1957-1958  
Adams Prize (Cambridge University)
- (1961) First recipient of Maxwell Medal and Award (Physical Society, London)
- (1964) Hughes Medal (Royal Society, London)
- (1971) J. Robert Oppenheimer Memorial Medal and Prize (University of Miami)
- (1976) Guthrie Medal and Prize (Institute of Physics, London)
- (1977) Sir Devaprasad Sarvadhikary Gold Medal (Calcutta University)
- (1978) Matteucci Medal (Accademia Nazionale dei XL, Rome)  
John Torrence Tate Medal (American Institute of Physics)  
Royal Medal (Royal Society, London)
- (1979) Nobel Prize for Physics (Nobel Foundation)  
Einstein Medal (UNESCO, Paris)  
Shri R.D. Birla Award (Indian Physics Association)
- (1980) Josef Stefan Medal (Josef Stefan Institute, Ljubljana)
- (1981) Gold Medal for outstanding contributions to physics (Czechoslovak Academy of Sciences, Prague)
- (1983) Lomonosov Gold Medal (USSR Academy of Sciences)

## **7. Awards for Contributions towards Peace and Promotion of International Scientific Collaboration**

- (1968) Atoms for Peace Medal and Award (Atoms for Peace Foundation)
- (1981) Peace Medal (Charles University, Prague)
- (1986) Premio Umberto Biancamano (Italy)  
Dayemi International Peace Award (Bangladesh)

## **8. Academies and Societies**

- (1954) Elected, Fellow, Pakistan Academy of Sciences (Islamabad)

- (1959) Elected, Fellow of the Royal Society (London)
- (1970) Elected, Fellow, Royal Swedish Academy of Science (Stockholm)
- (1971) Elected, Foreign Member of the American Academy of Arts and Sciences (Boston)
- Elected, Foreign Member, USSR Academy of Sciences (Moscow)
- (1979) Elected, Foreign Associate, USA National Academy of Sciences (Washington)
- Elected, Foreign Member, Accademia Nazionale dei Lincei (Rome)
- Elected, Foreign Member, Accademia Tiberina (Rome)
- Elected, Foreign Member, Iraqi Academy (Baghdad)
- Elected, Honorary Fellow, Tata Institute of Fundamental Research (Bombay)
- Elected, Honorary Member, Korean Physics Society (Seoul)
- (1980) Elected, Foreign Member, Academy of the Kingdom of Morocco (Rabat)
- Elected, Foreign Member, Accademia Nazionale delle Scienze (detta dei XI), (Rome)
- Elected, Member, European Academy of Science, Arts and Humanities (Paris)
- Elected, Associate Member, Josef Stefan Institute (Ljubljana)
- Elected, Foreign Fellow, Indian National Science Academy (New Delhi)
- Elected, Fellow, Bangladesh Academy of Sciences (Dhaka)
- (1981) Elected, Member, Pontifical Academy of Sciences (Vatican City)
- Elected, Corresponding Member, Portuguese Academy of Sciences (Lisbon)
- (1983) Founding Member, Third World Academy of Sciences (Trieste)
- Elected, Corresponding Member, Yugoslav Academy of Sciences and Arts (Zagreb)
- (1984) Elected, Honorary Fellow, Ghana Academy of Arts and Sciences
- (1985) Elected, Honorary Member, Polish Academy of Sciences
- (1986) Elected, Corresponding Member, Academia de Ciencias Medicas, Fisicas y Naturales de Guatemala
- (1986) Elected Honorary Life Fellow, London Physical Society
- Elected, Fellow, World Academy of Art and Science (Stockholm)
- (1987) Elected, Corresponding Member, Academia de Ciencias Fisicas, Matematicas y Naturales de Venezuela

Elected, Fellow, Pakistan Academy of Medical Sciences  
Elected, Foreign Fellow, African Academy of Sciences

## 9. Orders

- (1979) Order of Nishan-e-Imtiaz (Pakistan)
- (1980) Order of Andres Bello (Venezuela)
- Order of Istiqlal (Jordan)
- Cavaliere di Gran Croce dell'Ordine al Merito della Repubblica Italiana

## 10. D.Sc. Honoris Causae

- (1957) Panjab University, Lahore, Pakistan
- (1971) University of Edinburgh, Edinburgh, UK
- (1979) University of Trieste, Trieste, Italy
- University of Islamabad, Islamabad, Pakistan
- (1980) Universidad Nacional de Ingenieria, Lima, Peru
- University of San Marcos, Lima, Peru
- National University of San Antonio Abad, Cuzco, Peru
- Universidad Simon Bolivar, Caracas, Venezuela
- University of Wroclow, Wroclow, Poland
- Yarmouk University, Irbid, Jordan
- University of Istanbul, Istanbul, Turkey
- (1981) Guru Nanak Dev University, Amritsar, India
- Muslim University, Aligarh, India
- Hindu University, Banaras, India
- University of Chittagong, Bangladesh
- University of Bristol, Bristol, UK
- University of Maiduguri, Maiduguri, Nigeria
- (1982) University of the Philippines, Quezon City, Philippines
- (1983) University of Khartoum, Khartoum, Sudan

- (1984) Universidad Complutense de Madrid, Spain  
The City College, The City University of New York, New York, USA
- (1985) University of Nairobi, Nairobi, Kenya  
Universidad Nacional de Cuyo, Cuyo, Argentina  
Universidad Nacional de la Plata, La Plata, Argentina  
University of Cambridge, Cambridge, UK  
University of Goteborg, Goteborg, Sweden
- (1986) Kliment Ohridski University of Sofia, Sofia, Bulgaria  
University of Glasgow, Glasgow, Scotland  
University of Science and Technology, Hefei, China  
The City University, London, UK
- (1987) Panjab University, Chandigarh, India  
Medicina Alternativa, Colombo, Sri Lanka  
National University of Benin, Cotonou, Benin

## **11. Pakistan Assignments**

- (1958-74) Member, Atomic Energy Commission, Pakistan
- (1959) Adviser, Education Commission Pakistan  
Member, Scientific Commission, Pakistan
- (1961-62) Elected President, Pakistan Association for Advancement of Science
- (1961-74) Chief Scientific Adviser to President of Pakistan
- (1961-64) Founder Chairman, Pakistan Space and Upper Atmosphere Committee
- (1962-63) Governor from Pakistan to the International Atomic Energy Agency
- (1963-75) Member, National Science Council, Pakistan
- (1973-77) Member, Board of Pakistan Science Foundation

## **12. Pakistani Awards**

- (1959) Sitara-i-Pakistan (S. Pk.)

- (1979) Pride of Performance Medal and Award  
The Order of Nishan-e-Imtiaz (the highest civilian award)

### 13. As "Servant of Peace"

- (1968) Awarded the Atoms for Peace Medal and Award (Atoms for Peace Foundation)  
(1970- ) Member, Scientific Council, SIPRI (Stockholm International Peace Research Institute)  
(1981) Peace Medal (Charles University, Prague)  
(1981-86) Member, Council, University for Peace, Costa Rica  
(1986) Premio Umberto Biancamano (Italy)  
Dayemi International Peace Award (Bangladesh)

### 14. Published Papers

Around 250 scientific papers on physics of elementary particles. Papers on scientific and educational policies for developing countries and Pakistan.

### 15. Scientific Contributions

Research on physics of elementary particles. Particular contributions:

- (i) two-component neutrino theory and the prediction of the inevitable parity violation in weak interaction;
- (ii) gauge unification of weak and electromagnetic interactions – the unified force is called the "Electroweak" force – a name given to it by Abdus Salam; predicted existence of weak neutral currents and W, Z particles before their experimental discovery;
- (iii) symmetry properties of elementary particles; unitary symmetry;
- (iv) renormalization of meson theories;

- (v) gravity theory and its role in particle physics; two tensor theory of gravity and strong interaction physics;
- (vi) unification of electroweak with strong nuclear forces, grand (electro-nuclear) unification;
- (vii) related prediction of proton-decay;
- (viii) supersymmetry theory, in particular formulation of superspace and formalism of superfields.

## 16. Books

*Symmetry Concepts in Modern Physics*, Iqbal Memorial Lecture, (Atomic Energy Centre, Lahore), 1966.

Edited with E.P. Wigner, *Aspects of Quantum Mechanics*, (Cambridge University Press), 1972.

Biography, *Abdus Salam*, by Dr. Abdul Ghani, (Ma'aref (Printers) Limited, Defence Housing Society, Karachi), 1982.

*Ideals and Realities, Selected Essays of Abdus Salam*, Edited by Z. Hassan and C.H. Lai, World Scientific Publishing Co.Pte.Ltd.,1984. Translated into Arabic, Chinese, Italian, Persian, Urdu, Rumanian, Russian and Spanish with Portuguese, Japanese, and French in progress.

With Ergin Sezgin, *Supergravity in Diverse Dimensions*, Vols. I and II, to be published by World Scientific Publishing Co. Pte. Ltd. in 1987.

*Science and Education in Pakistan*, The Third World Academy of Sciences, Trieste, Italy, 1987.

*A Man of Science*, Research Centre for Cooperation with Developing Countries, Ljublijana, Yugoslavia, 1987.

